eISBN 978-967-288-84-4

TLIF Proceedings 2024

Teaching and Learning Innovation Festival

Hilmi Mukhtar
Noorzareith Sofeia Noordin
Amuthageetha Nagarajan
Veeradasan Perumal



TLIF Proceedings 2024

Teaching and Learning Innovation Festival

14th November 2024

TLIF Proceedings 2024

Teaching and Learning Innovation Festival

eISBN 978-967-2880-84-4

TLIF 2024 Editorial Board
Veeradasan Perumal

Secretariat
Des Iskandar bin Ismail

The Teaching and Learning Innovation Festival 2024 (TLIF 2024), organised by the Centre for Academic Excellence (CAdEx) at Universiti Teknologi PETRONAS, is a biennial event that showcases the transformative power of innovation in academia. As we celebrate the 9th edition of TLIF, participants will be able to engage with cutting-edge ideas that enrich the student learning journey and drive positive change in higher education.

Under the theme "Innovation in Teaching and Learning Practices," TLIF 2024 will highlight transformative and innovative ideas and practices across several key sub-themes:

- Transformative Teaching and Learning
- Immersive Learning
- Technology and Digital Innovation
- Student-Centered Learning
- Diversity and Inclusivity

The festival aims to disseminate knowledge that will enhance the future quality of education and foster a positive student experience.

© Universiti Teknologi PETRONAS, 2025

All rights reserved. No part of this publication may be reproduced or transmitted in any form or any means, including photocopying and recording, without the written permission of the copyright holder, the application for which should be addressed to Universiti Teknologi PETRONAS. Such written permission must also be obtained before any part of this publication is stored in a retrieval system of any nature. The publisher, authors, contributors and endorsers of this publication each exclude liability for loss suffered by any person resulting in any way from the use of or reliance on this publication.

Published by
UTP PRESS
Universiti Teknologi PETRONAS , 32610 Seri Iskandar Perak Darul Ridzuan, Malaysia
Owned by Institute of Technology Petronas Sdn Bhd

Address
TLIF 2020 Editor-in-Chief,
Universiti Teknologi PETRONAS, 32610 Seri Iskandar,
Perak Darul Ridzuan, Malaysia.

Typeset by
UTP PRESS, Universiti Teknologi PETRONAS
32610 Seri Iskandar Perak Darul Ridzuan
Owned by Institute of Technology Petronas Sdn Bhd

Contents

1	The Mediating Role of Social Learning in the Relationship between Smart Teaching Environment, Classroom Design, E-Learning, Learning Ability and Teaching Quality among University Students in Klang Valley *Che Rosmawati Che Mat, Arman Hj Ahmad, Alisa Ibrahim, Wan Toren Wan Yusoff, Nor Nasuha Sukri, Muhammad Syirazie Hafiez*	1
2	Transformative Learning: Changing Perspectives on Counselling Through Gardening *Dini Farhana Baharudin, Ainurliza Mat Rahim*	38
3	Revolutionising Engineering Education by Integrating Structured Problem-solving and Industry Engagement in Project-based Learning *Azlan Ahmad, Oh Pei Ching, Zahiraniza Mustaffa, Nursyarizal Mohd Nor, Nurhayati Mellon*	42
4	Enhancing Geo-field Camp with Interactive Learning: Pre-fieldwork Simulations and H5P Tools *Nor Syazwani Zainal Abidin*	52
5	Enhancing Civil Engineering Education: A Framework for Mobile-learning and Project-Based Learning Integration *Salmaliza Salleh, Jeena Reji, Panos Kloukinas*	59
6	Empowering Future Leaders: The Transformative Impact of Action-based Learning at INCEIF *Zulkarnain Muhamad Sori, Nurshakira Hairudin, Asmawi Asari, Mohd Norhisham Mohamad*	63
7	Visualizing Trigonometric Applications through Digital Comics *Noraini Jamaludin*	67
8	Enhancing AI Learning Outcomes through Peer-Coaching in Flipped Classrooms: A Controlled Study *Ramani Kannan, Khairul Nisak Md Hasan, Mohammed Isam Al-hiyal, Vishal Jain*	74

9	Exploring The Motivational Impact of Stage Sketches on Student-Centered Learning *Nurul Izni Kairi*	81
10	Enhancing Student Engagement and Learning Outcomes through Game-based Learning *Teh Hee Min*	95
11	Safeload: Enhancing HSE Training through Immersive Metaverse Experience *Ariff Imran Rostam, Khairul Shafee Kalid, Gehad Mohamed Ahmed Naji, Savita Sugathan, Ahmad Adib Safariel Sahadan*	101
12	Next-gen Learning: A Novel Integration of AR, AI, and Spatial Computing in Student-Centric Education *Daniel Tonye Oyefidein, Precious Ada Josiah*	105
13	Enhancing Student Engagement and Performance in Engineering Mathematics Course: A Blended and Cooperative Learning Approach *Mohana Sundaram Muthuvalu , Majid Khan Majahar Ali, Jumat Sulaiman*	109
14	Fostering Innovation in Mechatronics: Integrating the Double Diamond Design Thinking Model *Veeradasan Perumal, Saravanan Karuppanan, Mark Ovinis*	113
15	Mindfulness Expressive Art-Therapy (MEAT) in Improving Students' Observation Skills: A Case Study from Structural Geology Course *Siti Nur Fathiyah Jamaludin, Nur Hidayat Jamalludin*	116
16	Enhancing Learning Experiences, Engagement, and Learning Outcomes through Short-Term Project-Based Learning: A Case Study in The Formation Evaluation Course of Petroleum Engineering *Sia Chee Wee, Muhammad Aslam Md Yusof*	121
17	Evaluating Effectiveness of Project-based Learning at Universiti Teknologi PETRONAS *Hassan Soleimani, Amir Rostami, AKM Eahsanul Haque*	123
18	Enhancing Practical Competency and Teamwork in Petroleum Engineering Students through Open-ended Laboratory Assessments *Nur Asyraf Md Akhir, Sia Chee Wee, Muhammad Aslam Md Yusof*	129
19	SafetyVerse: Virtual Environment Development for Safety Training and Awareness *Muhammad Arif Hakimi Ismadi, Savita Sugathan, Manoranjitham Muniandy*	137
20	'Tearning': Blending Teaching and Learning into a Unified Student-Centered Educational Experience *Daniel Tonye Oyefidein, Precious Ada Josiah, Shamsuddeen Adamu*	142

21	Immersive Technology of VR Is Revolutionising the Learning Experience for Applied Chemistry Students: Navigating Complex Operations of Wastewater Treatment Plant *Jun Wei Lim*	147
22	Designing A Computer Networks Course with Active Learning and Gamification Approach *Junaid Shuja, Muhammad Ali Humayun, Abdullateef Oluwagbemiga Balogun, Mohd Hilmi Hasan*	151
23	Enhancing Clinical Learning with Artificial Intelligence: Improving Creativity and Critical Thinking through AI-Generated Clinical Case Studies *Zaswiza Mohamad Noor*	160
24	Assessing the Impact of Blended Learning on First-Year Chemical Engineering Students *Lam Man Kee, Chew Thiam Leng, Chai Yee Ho*	163
25	Augmented Reality Application of Gas Turbine to Enhance Skills and Learning Experience for Trainees *Muhamad Syakirin Abdul Khalid, Noreen Izza Arshad, Nur Irdina Nadira Mohd Dzahir, Mohamed Imran Mohamed Ariff*	166
26	Combining Smartphone Technology and Microlearning as a Learning Strategy for Thermodynamics Subject *Hazlina Husin, Amni Haslinda Alpandi*	172
27	Interactive Learning of Linear Algebra through Augmented Reality Visualization *Zazilah May, Gurwinder Singh*	178
28	MetaShield: Cybersecurity Awareness for O'Week *Lenuga M.Mathivanan, Savita Sugathan, Manoranjitham Muniandy*	182
29	Development of an Immersive Virtual Reality Module for High Voltage Laboratory *Mohd Fakhizan Romlie*	188
30	Course Delivery Via Blended Learning Supported by Flipped Classroom and Active Learning Techniques *Chew Thiam Leng*	191
31	Innolead-Biz: Transformative Teaching and Learning Model for Innovation in Education Course *Nurhasmiza Sazalli, Wan Farah, Wani Wan Fakhruddin*	197
32	The Impacts of Teacher Diversity and Students' Engagement on Students' Academic Performance in Malaysian GLU Universities: A Proposed Quantitative Study *Arman Hj. Ahmad, Che Rosmawati Che Mat, Hadezah Amit, Anis Abd Razak, Mohd Juraij Abd Rani, Nasution Ismail*	201

33 Leveraging Peer Teaching to Enhance Conceptual Understanding in Statics and Dynamics for a First-Year Student Experience 209
Mazlin Idress, Mazuin Jasamai,

34 Empowering Microprocessor Students to Attain Knowledge and Skills using 32-bit ARM Processor Kits through Practical Task and Project Undertakings 213
Mohd Zuki Yusoff

35 Integrating Virtual Reality to Enhance Petroleum Engineering Education: A Case Study in Drilling Engineering 216
Muhammad Aslam Md Yusof, Nurrul Hazwani Abu Bakar

36 Development of Storyboard for an Interactive 360 Virtual Reality Tour of a Combined Cycle Power Plant for an Engineering Course - Process Heat Transfer 220
Wan Zaireen Nisa Wan Yahya, Shafirah Samsuria, Pai Jun Jie

37 Understanding National Income Mechanism: An Experiential Simulation of Aggregate Demand and Supply Dynamics 228
Ding Hooi Ting

38 Visualizing 2D Model and Understanding Functions through Desmos 231
Farahani Yusoff, Wan Sharizan Wan Mamat Pauzam

39 The Readiness of the Psychology Lecturer to Implement VR Case Study, VR to Stimulate Real-world Experiences and Improve Knowledge Retention 235
Siti Aminah Harun, Wan Nabilah Syafiqah Wan Abd Rahim, Nur Shyuhadah Rasli

40 Enhancing Student Development through Problem-Based Learning in Physics: Integrating Scientific Research and Soft Skills for Real-world Applications 238
Easter Joseph, Nurul Izzah Mohd Ridwan

41 Enhancing Student Engagement and Learning through Class Kick Strategies 242
Numair Siddiqui, Mohamed M Abdo Aly Elsaadany, Syed Harron, Mona Arif Muda, Manoj Mathew

42 Collaborative Learning through Role-Playing: Enhancing System Design Skills in Students 246
Zuraini Hanim Zaini, Shakirah Mohd Taib

43 Uncovering the Story of Earth's Formation through Treasure Hunt Activities 251
Mazuin Jasamai, Mazlin Idress, Zuraini Ismail, Hilmayeni Suardi

44 From Rig Operations to Classrooms: Storytelling in Geoscience Education 254
Mohamed M Abdo Aly Elsaadany, Numair Ahmed Siddiqui, John Oluwadamilola Olutoki

45 Blended Learning in Engineering Mathematics 1 Integrates Mathematical Thinking and Creative Problem-solving 259
Zazilah May, Dennis Ling Chuan Ching

46	Enhancing Graduates' Employability Skills via Industrial Training: an Employer's Perspective *Noor Hilyati Alilah, Nurul Naim Ahmad Rasli, Nor Hafizah Abdul Latif Khan*	262
47	Inquiry-based Learning on Engineering and Science Students: A Review *Syed Muhammad Yasir Ashrafi, Wesam Salah Alaloul, Muhammad Ali Musarat*	267
48	Developing Academic Resilience for Engineering Students through Application of Flipped Learning *Mysara Eissa Mohyaldinn*	277
49	Transforming Education with Project-Based Learning (PBL): Student Engagement in Dashboard Development for HR Management *Emelia Akashah, Shuhaida Shuhidan, Nurul Aida Osman, Najihah Zafira Zailai*	280
50	Catalysing Change: Transformative Teaching and Learning with Sustainable Business Innovations *Mohd Herry Bahador*	283
51	Enhancing English Communication Skills for Japanese Gen Z University Students through AI-Integrated Cross-cultural Learning Module *Nurhasmiza Sazalli, Nuraqilah Nadjwa Miskam, Izyanie Khazali*	287
52	Monitoring Student Progress through Continuous Online Questionnaires of the Learning Materials *Mohd Hilmi Noh*	292
53	Augmented Reality: A New Frontier in Learning Computer Internal Systems *Saipunidzam Mahamad, Suziah Sulaiman, Ahmad Nuris, Iqmal Faizul, Chin Yi Han*	295
54	Implementation of Blended Learning Method in Separation Process *Khairiraihana Johari, Chuah Chong Yang*	298
55	Contribution of Post Graduate Researchers to Support Innovative Teaching and Learning for Undergraduates: Examples from the Geoscience Department, UTP *Touhid Hossain, Maman Hermana*	303
56	Assessing Student Perceptions of Diversity Awareness and Inclusion Practices at Universiti Teknologi PETRONAS *Hafizan Mat Som, Nur Syadhila Che Lah*	308
57	Enhancing Civil Engineering Education: A Student-centred Framework for Integrating Adjunct Lectures and Site Visits *Bashar Mohammed*	313
58	How to Plan and Conduct a Physical Field Trip to Enhance Student Learning Experience *Yeong Yin Fong*	315

59 Metaverse in Education: Enhancing ESL Students' Learning Experience through Virtual Psychogeographical Exploration 319
Mohd Fadhli Shah Khaidzir, Mafarhanatul Akmal Ahmad Kamal

60 Laboratory Experiences Supplement and Stimulate Materials Science for Chemical Engineering Class 322
Noridah Osman

61 Enhancing Comprehension of the First Law of Thermodynamics through a Hot Air Balloon Project 332
Mior Azman Said, Nursyarizal Mohd Nor, Abdelrahman Khedir, Mohamed Gasmelseed

62 Enhancing Student Engagement through Collaborative Learning Tools in Blended Learning Environments 334
Suriana Ismail, Husna Sarirah Husin, Norhatta Mohd

63 Understanding Market Efficiency: Mechanisms, Implications, and Challenges 337
Farhan Mirza

64 Application of Active Learning In Engineering Design-based Module 341
Revathi Raviadaran

65 Impact of Teaching Styles on Undergraduates' Motivation and Acceptance towards Learning Laboratory-Based Subjects 346
Amni Haslinda Alpandi, Hazlina Husin

66 Technology Enhanced Learning: A Pathway to Education 4.0 350
Nasir Shafiq

67 Kanban Method for Agile Teaming and Project Management in MVP-Engineering Team Project I 352
Lila Iznita Izhar, Bingi Sai Venkata Naga Kishore, Azlan Ahmad, Oh Pei Ching, Nursyarizal M Nor, Huzein Hawari Fahmi

68 Integration of Augmented Reality (AR) for Enhancing Safety Protocols through Standard Operating Procedures (SOP), Job Safety Analysis (JSA), and Hazard Identification, Risk Assessment and Risk Control (HIRARC) 359
Dzulkarnain Zaini

69 Transformative Teaching: A Design Thinking Approach to Co-creating Knowledge in the Classroom 363
Amjad Shamim

70 Connecting the Dots: Engaging Students through Game-Based Learning with a Blockchain Game 366
Mazeyanti Mohd Ariffin, Noreen Izza Arshad, Nazleeni Samiha Haron

71	PLC-based Industrial Automation and Control Education through Virtual Labs: Integrating Digital Tools in Education 5.0 *Bingi Sai Venkata Naga Kishore, Rosdiazli Ibrahim, Madiah Omar*	371
72	Enhancing Engineering Education in Drilling Fluids and Cementing Technology through Active Learning Strategies *Raja Rajeswary Suppiah*	374
73	Implementing Technology and Digital Innovation for Capstone Design Project in Civil Engineering *Ahmad Mahamad Al-Yacouby*	377
74	Transforming Education in Malaysia: A Case Study of Multidisciplinary Project-Based Learning for Future-ready Graduates at Universiti Teknologi PETRONAS *Zulkifli Merican Aljunid Merican*	381
75	3D Printing Technology Applications for Enhanced Teaching and Learning for Engineering Drawing Education *Khurram Altaf*	386
76	Enhancing Student and Learning Experience Based on Eda Tools Coupled with Goals Framework *Socheatra Soeung, Norashikin Yahya, Micheal Drieberg*	391
77	Effective Teaching Method with Integration of Slido and No-hands Apps *Kamaluddeen Usman Danyaro*	396
78	Integrating Virtual Reality for Enhancing Students' Understanding in Circuit Theory Education *M. Drieberg, A. A. Aziz, K. N. M. Hasan, P. Sebastian, L. H. Hiung*	406
79	Incorporating Non-fungible Tokens (NFTs) in Teaching and Learning (T&L) Activities *Yee Ho Chai, Man Kee Lam, Thiam Leng Chew*	409
80	Transforming Education with Problem-based Learning Strategy for Mechanical Engineering Specialization Course *Davannendran Chandran*	412
81	Elevating Business Networking Training in Virtual Reality: Empowering Human-like Non-player Character Interactions through Large Language Models *Haarinesh Selvaraju*	415
82	The Role of Transformative Teaching in Enhancing Critical Thinking and Engagement: A Systematic Review in the Malaysian Education Sector *Nurul Syafiqah Azman, Affendy Abu Hassim, Muhd Farid Shamsudin*	422

83 Adopting Immersive Technology in Automotive Vocational Education: A Comprehensive Review 439
Nur Syadhila Che Lah, Hafizan Mat Som, Luqman Hakim Mohd Roslan, Amzari Jihadi Ghazali

84 Innovative Learning: Leveraging ChatGPT in Engineering Coursework through the SAMR Framework 443
Iskandar Dzulkarnain, Sia Chee Wee

85 Podcast Production Role-play: Enhancing Peer Collaboration by USIM Learning Communities 447
Ainurliza Mat Rahim, Dini Farhana Baharudin

86 Transformative Teaching and Learning in Service Learning (SULAM) Approach 451
Adzidah Yaakob, Dina Imam Supaat, Abidah Abdul Ghafar, Nurfadhilah Che Amani, Suraiya Osman, Fadhlina Alias

The Mediating Role of Social Learning in The Relationship Between Smart Teaching Environment, Classroom Design, E-Learning, Learning Ability, and Teaching Quality Among University Students in Klang Valley

Che Rosmawati Che Mat*[1], Arman Hj. Ahmad[1], Alisa Ibrahim[2], Wan Toren Wan Yusoff[1], Nor Nasuha Sukri[1], Muhammad Syirazie Hafiez Abdul Aziz[1]
[1]Universiti Kuala Lumpur Business School, Malaysia
[2]Universiti Teknologi MARA, Shah Alam, Malaysia
*che.rosmawati@unikl.edu.my

Introduction

In higher education, the proliferation of smart teaching environments has fundamentally altered traditional pedagogical approaches due to the rapid advancement of educational technology. These environments, which integrate digital platforms, adaptive learning systems, and real-time feedback mechanisms, provide educators with the resources necessary to develop more effective and personalised learning experiences (Zawacki-Richter et al., 2019) E-learning, clever teaching resources, classroom design, learning ability, and the broader smart teaching environment are all critical components of these environments. In conjunction, they are essential in improving the quality of instruction, with social learning as a mediating factor. To deliver interactive and adaptive learning experiences that are tailored to the unique requirements of students, smart teaching environments implement cutting-edge technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data analytics (Wang et al.,2024). In addition to facilitating more informed and effective instruction, these technologies also enable educators to collect real-time data on student performance. According to Smith et al. (2023), the educational experience is further improved by incorporating intelligent teaching resources, including digital textbooks, virtual laboratories, and e-learning platforms offering personalised and immersive content. Specifically, e-learning allows students to interact with course materials at their own pace and convenience, which has been demonstrated to be essential in contemporary education (Graham, 2021).

Learning ability is a critical factor in the educational process, particularly in intelligent teaching environments. Cognitive processing is enhanced, and student engagement and outcomes are enhanced by adaptive learning technologies that customise instruction to meet the unique requirements of each student (Sari, Tumanggor, & Efron, 2024).Classroom design is also a critical factor in improving the efficacy of teaching. A learning environment that encourages active participation and deeper learning is fostered by physical and virtual classrooms designed for technological integration, collaboration, and flexibility (Tondeur et al., 2024).The fundamental aspect of these interactions is social learning, in which students acquire knowledge through observation, imitation, and collaboration with their peers (Bandura, 1977). Social learning is facilitated by intelligent teaching environments that encourage peer-to-peer engagement through collaborative technologies, thereby enhancing the quality of teaching and learning outcomes (Chen et al., 2020).

There is still a lack of comprehension regarding how these diverse factors – e-learning, smart teaching resources, learning ability, classroom design, and the broader smart teaching environment – interact to impact the quality of teaching despite the potential benefits of smart teaching environments. Social learning by inadequate training and support to effectively utilise smart teaching resources (Huang, Liu, & Tlili, 2021) Further complicating the successful implementation of these technologies are the disparities in digital literacy among students and educators, which result in a digital divide that impacts educational outcomes (Lopez & Edwards, 2020).

This research investigates the combined impact of smart teaching resources, e-learning, learning ability, classroom design, and the smart teaching environment on teaching quality, with social learning as a mediating factor. In doing so, it addresses these gaps. The study intends to offer a thorough comprehension of how contemporary educational technologies can be employed to enhance the quality of instruction in higher education by investigating these relationships. According to Zhang dan Wu (2021)., the results are anticipated to provide educational policymakers and institutions with guidance on the most effective methods for incorporating smart teaching technologies, thereby enhancing the effectiveness of educator training programs. This research also contributes to the ongoing discussion on the role of technology in education by providing valuable insights into the optimal conditions for utilising smart teaching environments to improve the quality of instruction(Zhang, et al., 2024).

The creative aspect of this research is its comprehensive approach, which investigates the cumulative influence of numerous variables on the quality of instruction. Unlike previous research that has concentrated on individual components such as e-learning or smart teaching resources, this study investigates how these elements, as well as learning aptitude and classroom design, interact with social learning to influence the quality of teaching. A more nuanced comprehension of the collective impact of these factors on educational outcomes is facilitated by this comprehensive approach. In addition, the research introduces the concept of "intelligent pedagogical design," which underscores the strategic integration of technology and pedagogy to optimise the effectiveness of instruction. This concept is especially pertinent in the context of smart teaching environments, where technology must be integrated into the educational process as a transformative element rather than solely a tool. In addition, the novelty of this research is its emphasis on the mediating role of social learning. Although traditional educational settings have been extensively investigated regarding social learning theory, its application in intelligent teaching environments has yet to be investigated. This study offers novel perspectives on the relationship between technology and pedagogy by examining how social learning improves the efficacy of e-learning, clever teaching resources, and classroom design. The potential to considerably enhance the quality of teaching by fostering a collaborative and interactive learning atmosphere is present when social learning is effectively integrated into smart teaching environments (Gao, & Ismail, 2025).

In conclusion, the objective of this research is to investigate the complex interrelations between the quality of teaching, social learning, and clever teaching environments. This study endeavours to offer a comprehensive comprehension of the effective integration of technology into higher education by analysing the aggregate impact of smart teaching resources, e-learning platforms, learning ability, and classroom design on teaching outcomes. In addition to enriching the academic literature, the results will provide practical advice to educators and policymakers on how to optimise the utilisation of intelligent teaching technologies in educational institutions, thereby improving the quality of instruction and revolutionising the educational environment.

Literature Review

A central theme in recent educational research has been the integration of technology into education, particularly in the context of the proliferation of smart teaching and learning environments. By offering personalised and adaptive learning experiences, these environments, which capitalise on cutting-edge technologies like AI, the IoT, and big data analytics, are designed to improve the quality of education. Smart teaching environments are the subject of a vast body of literature that addresses a variety of topics, including the efficacy of e-learning, the role of learning abilities, the impact of smart teaching resources, and the influence of classroom design. In this review, the theoretical frameworks that underlie these variables are examined and the current research on them is synthesised.

Smart teaching environment

The educational experience is improved by the integration of adaptive systems, interactive tools, and advanced technologies in a Smart Teaching Environment (STE), which promotes student engagement and enhances the quality of teaching. These environments are intended to establish dynamic, interactive, and personalised learning environments in which technology is instrumental in enabling student collaboration and content delivery. Digital whiteboards, virtual reality (VR)-powered learning systems, AI-powered learning systems, and the Internet of Things (IoT) devices are all essential components of a smart teaching environment, as they all contribute to the development of a responsive and connected educational environment (Wang & Wang, 2022).

Research has demonstrated that intelligent instructional environments significantly enhance the quality of instruction. For example, Sajja et al. (2024) discovered that AI-driven tools in STEs offer personalised learning experiences, enabling students to receive real-time feedback and adaptive learning trajectories based on their progress. This has been associated with enhanced academic performance and student engagement. In the same vein, collaborative technologies, including virtual learning platforms and interactive digital tools, promote a more participatory classroom environment and facilitate peer-to-peer learning. Consequently, students in STEs are more inclined to actively participate in course material, which improves their learning outcomes (Zhao & Chen, 2022).

Additionally, data-driven instructional decisions are enabled by intelligent teaching environments. Educators can monitor student performance and modify their teaching strategies as needed by integrating AI systems and IoT devices. For instance, Zhang et al. (2024) emphasised that the early identification of problematic students and the provision of targeted interventions enabled instructors to enhance the quality of instruction and student success through real-time data collection from smart classroom sensors and AI tools.

Nevertheless, the widespread adoption of STEs is impeded by several challenges despite the benefits they offer. One significant concern is the exorbitant cost of implementing smart technologies, which can result in disparities between institutions with varying financial capacities Barakabitze et al.,2019. Furthermore, educators must undergo appropriate training to implement intelligent teaching tools effectively, and numerous educators express that they are inadequately equipped to integrate these technologies into their instructional methodologies completely. The prospective benefits of STEs could remain underutilised if teacher training is insufficient, as emphasised by Zhan et al. (2021). Furthermore, the potential for a reduction in the emphasis on fundamental teaching skills, including critical thinking and student-teacher interaction, has been a subject of criticism in the classroom due to an excessive reliance on technology (Barakabitze et al., 2019).

In summary, the integration of advanced technologies in smart teaching environments can significantly improve the quality of instruction and student engagement. Nevertheless, it is imperative to address the obstacles of cost, teacher training, and appropriate pedagogical integration to fully realise the advantages of STEs. These environments represent a transition to more interactive, data-driven, and personalised learning; however, their success is contingent upon equitable access and deliberate implementation.

Smart Teaching Resources

Digital tools and materials employed to implement innovative teaching methods are referred to as "smart teaching resources". This category encompasses educational software, virtual and augmented reality applications, interactive textbooks, and online learning platforms. The body of literature indicates that these resources are essential for improving student engagement and learning outcomes. For instance, Smith et al. (2023) discovered that using interactive textbooks and virtual labs in science education significantly enhanced students' comprehension of intricate concepts and their capacity to implement knowledge in practical contexts. Smart teaching resources' efficacy is closely associated with their capacity to offer personalised learning experiences and real-time feedback. In 2024, Sari et al. reported that adaptive learning systems that employ AI to customise content to the specific requirements of individual students have demonstrated promising results in enhancing learning outcomes. The difficulty of tasks can be adjusted by these systems in accordance with a student's performance, thereby providing targeted support where necessary. Gligorea et al., (2023) previously underscored the significance of personalisation in educational technology, contending that it promotes retention and deeper engagement. This is consistent with their findings. Despite the prospective advantages, there are obstacles associated with the implementation of smart teaching resources. Some of these include the necessity of making substantial investments in technology infrastructure and the digital literacy of both students and educators. Disparities in access to technology and varying levels of digital literacy can result in inequalities in educational outcomes, as emphasised by Lopez and Edwards (2020). Consequently, despite the substantial benefits of intelligent teaching resources, their successful integration into educational environments necessitates a meticulous examination of these potential obstacles.

Learning Ability

A student's capacity to acquire, comprehend, and retain knowledge is a critical factor in the educational process, specifically their learning ability. The availability of technology-enhanced learning aids has created new opportunities to improve learning abilities through the implementation of smart instruction and learning environments. This has been particularly effective with adaptive learning technologies, which modify the difficulty level based on a student's performance. These technologies have the potential to considerably enhance the cognitive abilities of students by offering personalised learning experiences that cater to their unique strengths and weaknesses, as demonstrated by Sari, Tumanggar and Efron (2024). In addition, educators can closely monitor student progress and intervene, when necessary, by utilising learning analytics in smart teaching environments. Learning analytics tools allow educators to identify learning deficits and provide targeted support, thereby providing valuable insights into student performance, as per Johnson, Smith and Carter (2022). As students receive the necessary support to achieve success, this proactive approach not only improves their learning abilities but also cultivates a more supportive learning environment. The efficacy of these technologies in improving students'

learning abilities is, however, contingent upon their compatibility with the learning styles and preferences of the students. Although technology can offer personalised learning experiences, it may not be equally effective for all pupils, as Fredricks et al. (2021) observed. In technology-driven environments, certain students may experience difficulty with self-regulation, underscoring the necessity of adaptive systems that can accommodate a variety of learning style preferences.

E-Learning

In the aftermath of the COVID-19 pandemic, e-learning has become an essential component of contemporary education, defined as the utilisation of digital platforms and electronic media for educational purposes. The impact of e-learning on student outcomes and teaching quality is the subject of numerous studies in the extensive literature on e-learning. According to Graham (2021), e-learning provides numerous benefits over conventional classroom environments, such as the capacity to accommodate a variety of learning styles, accessibility, and flexibility. A flexible learning environment that can accommodate the requirements of a wide range of learners is one of the primary advantages of e-learning. Students who engaged in e-learning courses reported higher levels of satisfaction and engagement than those in traditional classroom contexts, according to Martin et al. (2022). The primary reason for this is the adaptability of e-learning, which enables students to learn at their own tempo and schedule. However, the quality of the digital content and the design of the learning platform are the primary factors determining the efficacy of e-learning. Poorly designed e-learning platforms can impede student engagement and result in inferior learning outcomes, as Wang, Mo, & Zhang (2023) observed. As a result, it is imperative to exercise caution when designing and implementing e-learning platforms to guarantee that they create a supportive and engaging learning environment. However, some obstacles must be resolved despite the advantages of e-learning. These include the digital divide, student motivation, and academic integrity. In particular, the digital divide presents a substantial obstacle to the widespread adoption of e-learning, as students from low-income backgrounds may not have access to the requisite technology and internet connectivity (Lopez & Edwards, 2020). Thus, despite the substantial potential of e-learning, its success is contingent upon resolving these obstacles.

Teaching Classroom Design

The learning environment and student outcomes are significantly influenced by the design of the educational classroom. Technology and adaptable configurations that facilitate student engagement and collaborative learning have become integral to contemporary classroom design. The utilisation of modular furniture, interactive whiteboards, and immersive learning spaces can significantly improve student engagement and cultivate a more inclusive learning environment, as per Tonduer et al. (2024). The literature indicates that the quality of instruction and students' success can be significantly influenced by the classroom's physical layout. Classroom design elements, including illumination, acoustics, and furniture arrangement, can significantly impact student motivation, concentration, and the overall learning experience, as Barrett et al. (2015) observed. Classrooms that are intended to be adaptable and flexible can more effectively accommodate a variety of learning activities and teaching methods, thereby improving the overall quality of education.

Additionally, the successful implementation of intelligent teaching environments necessitates the integration of technology into classroom design. Bicen and Kocakoyun (2022) underscored the significance of integrating digital infrastructure, including multimedia

tools and interactive displays, into classroom design. This integration enables the seamless integration of technology into teaching practices, thereby improving the efficacy of smart teaching environments. Nevertheless, the efficacy of these designs is contingent upon their compatibility with pedagogical objectives. Classroom design should not be solely determined by technological considerations, as Tonduer et al. (2024) noted that it should also be informed by the educational objectives and the students' requirements. Consequently, the design of teaching environments should be guided by a comprehensive comprehension of the educational process, which includes both pedagogical and technological factors.

Theoretical and Hypothesis Development

Integrated theoretical approach

In the contemporary educational environment, the quality of teaching has become a critical factor in determining the success of students and the overall character of education. An integrated theoretical approach that considers a variety of factors, including social learning, smart teaching environments, e-learning, classroom design, learning ability, and smart teaching resources, is necessary to comprehend the intricate influences on teaching quality. In order to accomplish this, an integrated theoretical framework can incorporate Social Learning Theory (SLT), Constructivist Learning Theory, Cognitive Load Theory (CLT), and the Technology Acceptance Model (TAM), each of which offers distinctive perspectives on the ways in which these variables interact to influence educational effectiveness.

Bandura's (1977) SLT underscores the importance of social interaction and observational learning in developing collaborative learning and student engagement. SLT elucidates how learners adopt behaviours and attitudes through observation and imitation in smart teaching environments where digital tools facilitate interaction. For instance, Liu et al. (2023) illustrated that social learning is improved in digital environments when interactive tools replicate real-world collaboration. This directly enhances the quality of teaching by more effectively engaging learners.

The active involvement of learners in constructing their understanding of the world is emphasised by constructivist learning theory, which is based on the work of Piaget (1954) and Vygotsky (1978). Bronkhorst and Meijer (2023) have conducted recent research that confirms the benefits of interactive and flexible classroom designs in the development of knowledge, as they create an environment that is conducive to critical thinking and exploration. A learner-centred approach, in which students actively engage with both physical and digital tools, facilitates deeper learning in smart teaching environments. This approach directly improves teaching quality by fostering critical thinking and autonomy in learning.

Sweller (2011) developed CLT, emphasising the optimisation of instructional design to enhance learning outcomes and mitigate extraneous cognitive burden. Mayer (2022) emphasises that well-designed digital resources can improve learners' cognitive processing abilities, as evidenced by recent advancements in digital learning platforms. CLT ensures that designing e-learning platforms and smart teaching resources in smart learning environments minimises unnecessary cognitive burdens, enabling students to concentrate on essential content. This directly affects the quality of instruction by enhancing students' capacity to retain and apply the material effectively.

Finally, the TAM, which was revised by Venkatesh and Bala (2008), continues to be indispensable for comprehending the adoption and utilisation of e-learning tools by educators and students. The acceptance of technology in contemporary learning environments is

influenced by its perceived utility and ease of use. When the tools were perceived as beneficial and user-friendly, the integration of AI and adaptive learning systems significantly increased student engagement and teaching quality, according to a recent study conducted by Oliveira et al. (2023). TAM is a critical element of the integrated framework, as it elucidates the manner in which these factors mediate the relationship between technology and educational outcomes.

The integrated framework offers a comprehensive comprehension of the interaction between variables such as social learning, smart teaching environments, classroom design, and technology adoption to improve the quality of teaching and learning by combining these theories. SLT offers a perspective on the significance of social interactions, Constructivist Learning Theory underscores the learner's active involvement in a well-designed environment, CLT emphasises the necessity of reducing cognitive load, and TAM elucidates technology's effective use and acceptance. Collectively, these theories establish a unified model that confronts the intricacies of contemporary educational environments, in which both traditional and digital instruments significantly influence the quality of instruction and learning results.

Smart Teaching Environment Relationship with Teaching Quality

A smart teaching environment is an educational setting that incorporates sophisticated

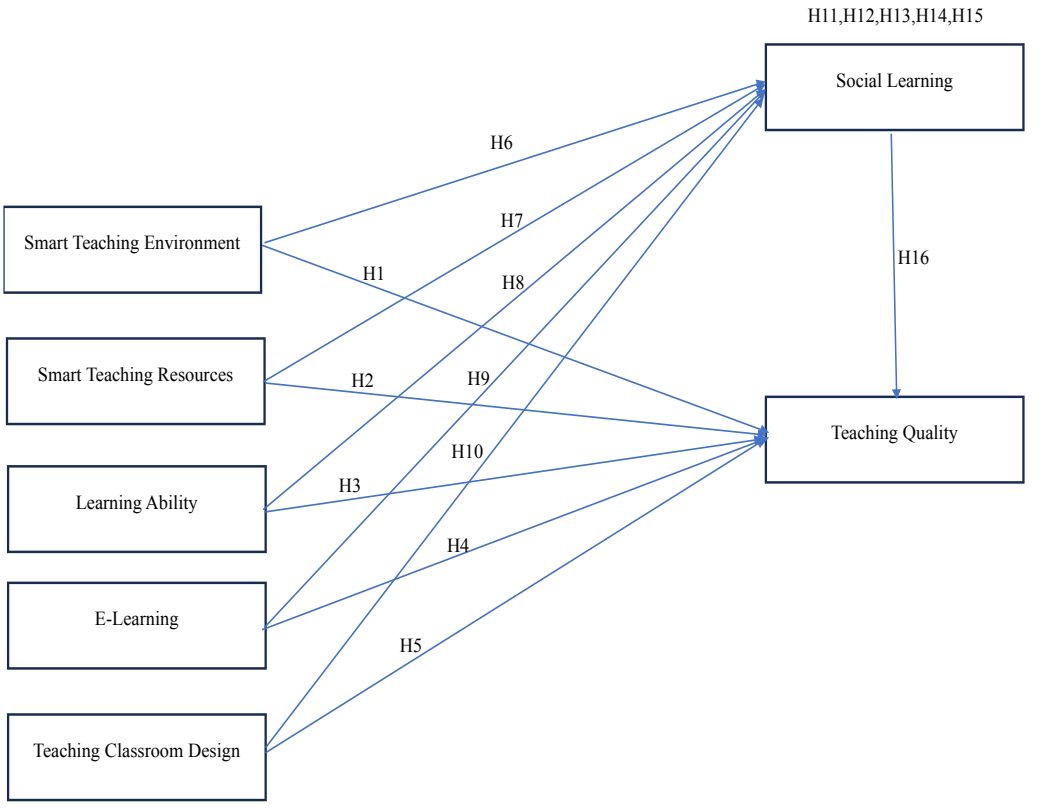


Figure 1 Research Framework (Integrated theoretical approach)

technologies to enhance the effectiveness and success of both teaching and learning experiences (Condie & Munro, 2007). Interactive whiteboards, digital content, VR, and AI applications are among the technological tools incorporated into these environments. The quality of instruction is significantly and multifacetedly influenced by technologically enhanced educational environments. These environments provide opportunities for personalised learning experiences that are customised to the individual learning styles, preferences, and requirements of students (Akçayır & Akçayır, 2017). For example, adaptive learning platforms employ data analytics to identify the strengths and shortcomings of students, thereby enabling educators to offer them personalised support and interventions. This personalised method not only enhances student engagement and learning outcomes but also the quality of teaching by addressing the unique challenges that individual students encounter (Zawacki-Richter et al., 2019).

Additionally, instructional environments that are intelligently designed facilitate interactive and collaborative learning experiences that are essential for contemporary education. Students can participate in group discussions, exchange ideas, and collaborate on projects regardless of their geographical location by utilising online platforms and technologies like video conferencing. In turn, this enhances the quality of instruction by fostering a sense of community and encouraging active participation, developing critical thinking, effective communication, and collaboration skills (Laurillard, 2012). Furthermore, VR and augmented reality (AR) technologies offer immersive learning experiences that significantly enhance the engagement and tangible nature of complex concepts. By providing students with vivid, interactive learning scenarios, these technologies substantially enhance teaching effectiveness, facilitating the comprehension and retention of complex subjects (Zarraonandia et al., 2021).

Additionally, smart teaching environments offer educators data-driven insights and tools that empower them to make well-informed educational decisions (Siemens & Long, 2011). Learning analytics systems have the capacity to monitor and evaluate student progress, evaluate learning outcomes, and offer immediate feedback to both students and instructors. By identifying areas where teaching can be improved, optimising teaching methods, and adapting content to meet evolving educational requirements, the strategic use of data enables continuous improvement in instructional practices (Wong et al., 2019). For instance, learning analytics can assist educators in identifying the curriculum components that pose the greatest difficulty for students and in adjusting their instructional strategies accordingly. This data-driven approach not only enhances the quality of instruction but also enables students to realise their maximum potential by offering personalised support that is customised to their unique learning requirements (Bates, 2019).

Incorporating these technologies into educational environments signifies a transition towards more inclusive, dynamic and engaging learning experiences. The capacity to personalise learning experiences and offer real-time feedback not only improves the efficacy of instruction but also equips students with the necessary skills to navigate the intricacies of the contemporary world. The potential for smart teaching environments to further enhance the quality of education is considerable as educational technologies continue to evolve, making it a critical area of focus for educators and policymakers (Zawacki-Richter et al., 2019). Consequently, the investigation's hypothesis is that;

H_1: Smart teaching environment significantly related to teaching quality

Smart Teaching Resources and Their Relationship with Teaching Quality

In the current digital era, integrating technology and innovative teaching methods is essential for improving the quality of education. The deployment of intelligent teaching resources, including interactive whiteboards, multimedia content, VR, and AI-driven platforms, is one of the most critical components of this evolution. These resources are intended to generate personalised learning experiences that are consistent with each student's learning patterns, preferences and requirements (Hwang et al., 2023). This personalised method, which employs AI to evaluate student data, allows educators to provide targeted interventions and assistance, thereby cultivating a more effective and engaging learning environment (Zawacki-Richter et al., 2019). Active learning is facilitated by intelligent teaching resources, which employ interactive technologies to convert inert learning into dynamic and immersive experiences. For instance, VR and gamified learning platforms enable students to interact with content in a more meaningful manner, which not only improves their comprehension of intricate concepts but also fosters critical thinking, creativity, and problem-solving abilities (Zarraonandia et al., 2021). These technologies are particularly effective in promoting collaboration among students, enabling them to collaborate in virtual environments, exchange ideas, and resolve issues in real-time. Ultimately, the quality of teaching is enhanced as a result of the collaborative nature of these clever resources, which facilitates the practical application of knowledge and a deeper understanding (Laurillard, 2012).

Additionally, the efficacy and effectiveness of instructional methods are improved by integrating data-driven insights and analytics through smart teaching resources (Siemens & Long, 2011). Learning analytics technologies monitor and evaluate student progress, measure learning achievements, and provide immediate feedback to students and instructors. Educators are able to make well-informed decisions about instructional strategies, identify areas where students may be struggling, and adapt their teaching methods accordingly to meet the diverse requirements of learners as a result of these data-driven approaches (Wong et al., 2019). Educators can considerably enhance the quality of instruction by optimising teaching tactics through the use of smart resources, thereby creating a more personalised, meaningful, and impactful learning experience for students. The instructional process is not only improved by the strategic use of smart teaching resources, but the broader objective of preparing students for the demands of the modern workforce is also supported. In order to guarantee that the quality of instruction remains consistent with the swiftly changing educational landscape, it will be imperative to effectively integrate these technologies as educational environments continue to evolve. Consequently, the investigation's hypothesis is that;

H_2: Smart teaching resources relationship significantly related to teaching quality

Relationship between Learning Ability and Teaching Quality

It is imperative to comprehend the relationship between teaching quality and learning ability in order to enhance educational outcomes. An individual's capacity to efficiently acquire, process, and retain knowledge is referred to as learning ability, while teaching quality incorporates the strategies, methods, and resources that educators employ to support learning. The complex relationship between these two variables has been increasingly emphasised in research, which emphasises that the quality of teaching has a profound impact on the learning capabilities of students (Hattie, 2023). In a variety of educational contexts, it has been demonstrated that effective teaching approaches that employ active learning methodologies, provide personalised instruction, and actively engage students can significantly improve academic performance and learning capability.

The implementation of individualised and customised instruction is a critical factor in the relationship between teaching quality and learning ability. Teachers facilitate the maximum potential of each student by customising their instructional strategies to accommodate the diverse needs, preferences, and abilities of their students. In order to optimise students' learning capabilities, differentiated instruction is indispensable, as it entails tailoring the content, process, and outcomes of learning to the unique characteristics of each student, as per Tomlinson et al. (2022). This methodology may involve the implementation of adaptive learning technologies, personalised learning plans, and multimodal teaching methods that are specifically designed to accommodate diverse learning styles. Teaching quality directly influences students' cognitive development, critical thinking abilities, and overall learning effectiveness by addressing individual differences and cultivating a supportive learning environment.

However, it is essential to recognise that not all research thoroughly supports the hypothesis that teaching quality is the most significant determinant of learning ability. According to certain studies, students' cognitive abilities, prior knowledge, and motivation are believed to have a more significant impact on their learning outcomes (Gao & Ismail, 2025) These factors may restrict the efficacy of even the most exceptional teaching, as students with low intrinsic motivation or cognitive challenges may find it difficult to capitalise on instructional strategies that are effectively implemented. Furthermore, the influence of teaching quality may be overshadowed by external factors, including socioeconomic status, access to resources, and familial support, which can also affect learning ability (Darling-Hammond et al., 2020).

In addition, although teaching quality can improve learning, there are instances in which excessively complex or sophisticated instructional methods may overwhelm students, particularly those with lower cognitive abilities, leading to a decrease in learning effectiveness (Kirschner et al., 2020). This implies that the relationship between learning aptitude and teaching quality is more complex than it may initially appear, and that a one-size-fits-all approach to teaching quality may not be universally beneficial. In conclusion, the positive correlation between teaching quality and learning ability is substantiated by a substantial body of evidence. However, it is crucial to acknowledge the constraints and obstacles associated with this relationship. A more intricate and nuanced comprehension of the interplay between these variables is facilitated by the potential drawbacks of specific teaching strategies, external factors, and individual student characteristics. Consequently, the investigation's hypothesis is that;

H_3: Learning ability significantly related to teaching quality

Relationship between E-learning and Teaching Quality

The accessibility and flexibility that e-learning platforms provide to both educators and learners considerably influence the relationship between e-learning and teaching quality. Asynchronous learning is facilitated by e-learning systems, which enable students to interact with instructors, access course materials, and engage in activities at their respective paces. This adaptability is designed to accommodate a wide variety of learning styles and preferences, thereby enhancing the personalisation and inclusivity of education (Wang et al., 2023). By enabling students to learn at their own pace, e-learning platforms assist educators in addressing the unique requirements of each learner, thereby improving the overall quality of instruction. The personalised nature of e-learning promotes enhanced learning outcomes, motivation, and increased student engagement (Ally, 2008).

Furthermore, interactive multimedia materials, simulations, and collaborative technologies are frequently implemented in e-learning environments, which are essential for improving the teaching and learning process. The integration of interactive elements, including gamified exercises, virtual laboratories, animations, and videos, not only enhances students' engagement but also enhances their understanding, retention, and application of intricate concepts (Zawacki-Richter et al., 2019). These instruments facilitate an immersive learning experience that encourages active engagement and a more profound comprehension of the subject matter. Furthermore, the utilisation of collaborative tools, including virtual classrooms, group projects, and discussion forums, enables the exchange of knowledge and peer interaction, which are indispensable for the cultivation of collaborative problem-solving, communication, and critical thinking abilities (Gašević et al., 2021). By offering students the chance to interact with the content and their classmates in a meaningful way, these collaborative environments significantly improve the quality of instruction.

Furthermore, e-learning environments enable educators to integrate learning analytics and assessment tools, thereby enabling them to employ data-driven approaches in teaching and learning environments. Learning management systems (LMS) and analytics platforms have the capacity to monitor student progress, acquire data on their performance, and produce valuable insights that inform instructional decisions (Siemens & Long, 2011). Educators can utilise these data-driven insights to identify learning deficits, assess the efficacy of their teaching strategies, and customise interventions to more effectively support student learning. E-learning platforms encourage the implementation of evidence-based teaching practices, which results in continuous improvement and more effective, personalised instruction, through the utilisation of data analytics (Wong et al., 2019). The potential of e-learning to enhance the quality of education is significant, particularly in its capacity to provide interactive, flexible, and personalised learning experiences. With the increasing adoption of e-learning technologies by educational institutions, the potential to improve the quality of instruction through these platforms will continue to expand. Therefore, this study hypothesizes that;

H_4: e-learning have significantly related to teaching quality

Relationship Between Teaching Classroom Design and Teaching Quality

Teaching quality and classroom design are substantially impacted by the promotion of student engagement and active learning. According to Tonduer et al. (2024), classroom designs that facilitate experiential learning, mobility, and interaction can significantly improve student engagement, critical thinking, and information retention. For example, the implementation of interactive learning stations, collaborative workstations, and flexible seating arrangements encourages student collaboration, active exploration of concepts, and exchange of ideas. Such arrangements foster an educational atmosphere that enables educators to develop lessons that promote inquiry, discussion, and practical application of knowledge, resulting in enhanced student performance and more profound learning experiences.

The integration of technology and digital resources, which are becoming increasingly important in modern education, is also significantly influenced by the physical arrangement of the classroom. Interactive displays, multimedia tools and digital learning platforms are just a few of the technological infrastructures that an effective classroom must have (Bicen & Kocakoyun, 2022). Moreover, these technologies contribute to developing students' digital literacy skills and improve the effectiveness of instruction by offering multimedia resources and interactive content.

Furthermore, adaptive learning platforms, virtual simulations, and online collaboration tools are implemented in classrooms that are equipped with technology to facilitate personalised learning experiences. The quality of instruction is enhanced by this personalised teaching approach, which caters to the students' diverse learning requirements and preferences of students.

Furthermore, the emotional and psychological well-being of students, as well as the overall educational environment, can be substantially influenced by the layout and design of a classroom. According to Barrett et al. (2015), the students' and educators' productivity, mood and comfort are influenced by factors such as ergonomically designed furniture, acoustics, colour schemes and natural illumination. A positive learning environment, distraction reduction and increased student motivation and focus are all facilitated by a well-designed and aesthetically appealing classroom. In addition to facilitating the teaching process, a comfortable and stimulating learning environment fosters a sense of inclusivity, creativity, and overall well-being, resulting in improved academic achievement and learning outcomes.

Nevertheless, it is crucial to recognise that classroom design is not the sole determinant of teaching quality, although it can have a substantial impact. In the end, the efficacy of a well-designed classroom is contingent upon the educators' utilisation of the space and resources at their disposal. Additionally, the optimisation of classroom designs may be restricted by financial constraints and institutional policies, which could impede their influence on the quality of instruction (Byers, Young & Imms, 2018). Consequently, the classroom's design is a critical element of effective teaching; however, it must be complemented by competent pedagogy, adequate resources, and supportive institutional frameworks to fully realise its potential benefits.

In conclusion, this investigation hypothesis is that the quality of instruction is significantly influenced by the design of the classroom. A classroom environment that is attentively designed has the potential to improve the educational experience by promoting the well-being of students and educators, integrating technology, and fostering active learning. Hence, this study hypothesizes that;

H_5: Teaching classroom design, have significantly related to teaching quality

Direct Relationship between Smart Teaching Environment and Smart Learning

The incorporation of technology into contemporary education has greatly revolutionised the process of acquiring knowledge, particularly through the advancement of Smart Teaching Environments. These environments, which are equipped with state-of-the-art digital tools, interactive platforms, and adaptive learning systems, offer many potential for improved collaboration and engagement, which are essential aspects of Social Learning. According to the Social Learning Theory (SLT) proposed by Bandura (1977), individuals acquire knowledge and skills by seeing, imitating, and engaging with others. Technologies in a smart classroom environment aid in peer engagement, feedback, and real-time cooperation, thereby enhancing social learning.

Studies have emphasised the beneficial effects of intelligent educational environments on social learning. Shi, Zhang and Chen (2023) discovered that the utilisation of interactive whiteboards, VR, and AI-driven tools in smart classrooms had a substantial positive impact on students' capacity to learn from their peers and acquire behaviours through observation. These technologies facilitate the creation of environments that promote improved cooperation, enabling learners to actively participate in social learning with more effectiveness.

Moreover, according to the findings of Wang and Wang (2022), smart teaching settings have been shown to enhance student engagement, motivation, and collaborative behaviour, all of which are crucial for facilitating effective social learning. Smart teaching environments enhance students' capacity to observe, imitate, and learn from others by providing interactive and flexible learning platforms that foster communication and engagement.

Nevertheless, not all research findings consistently endorse this correlation. According to Barakabitze et al. (2019) smart environments have the potential to increase engagement but may also restrict in-person social contacts, which are important for developing interpersonal skills. Hence, technology might not completely emulate the depth and complexity of real-life social learning encounters, which could impose certain constraints on its overall efficacy. Therefore, this study proposes the following hypothesis:

H_6: There is a positive direct relationship between the Smart Teaching Environment and Social Learning.

Direct Relationship Between Smart Teaching Resources and Social Learning

Smart Teaching Resources, which encompass digital tools, adaptive learning platforms, and interactive technology, have a crucial impact on the development of contemporary educational settings. These resources include many features, including immediate feedback, individualised learning paths, and collaborative platforms that are crucial for promoting Social Learning. Bandura's Social Learning Theory (SLT) posits that individuals acquire knowledge and skills by actively observing and engaging with others. Smart teaching tools facilitate digital platforms that enable learners to easily participate in observation, imitation, and collaborative learning processes.

Recent research has shown evidence for the effectiveness of intelligent educational materials in improving social learning. Nowadays, the use of digital tools, such as AI-powered feedback systems and collaborative learning platforms, has had a substantial positive impact on students' capacity to engage with their peers and enhance their learning through observation. These tools facilitate an atmosphere in which learners may actively interact with one another, exchanging knowledge and gaining insights from shared experiences, which are essential components of social learning.

In addition, a study conducted by Zhai et al. (2023) found that the presence of interactive digital resources, such as VR and online collaboration platforms, improves social learning by creating a more captivating and engaged learning atmosphere. These intelligent resources enable students to work together on projects, exchange valuable knowledge, and observe the actions of their peers, thereby strengthening social learning behaviours in both online and hybrid classroom environments.

Nevertheless, several experts advise that the efficacy of intelligent educational resources in facilitating social learning is contingent upon how these tools are employed. According to Barakabitze et al. (2019) excessive or inappropriate use of digital resources might impede direct, in-person social encounters, which are crucial for developing interpersonal skills and profound social learning. Incorporating Smart Teaching Resources into contemporary educational settings undoubtedly promotes Social Learning by enabling collaborative and interactive learning experiences. Digital tools, platforms powered by artificial intelligence, and virtual environments allow students to observe, mimic, and acquire knowledge from their classmates in ways that are frequently impossible in traditional classrooms. Recent research has demonstrated that these tools can improve learning outcomes by fostering social contact, facilitating peer feedback, and promoting knowledge sharing (Gao & Ismail, 2025).

Nevertheless, it is crucial to contemplate the equilibrium between digital engagements and conventional in-person encounters. According to Barakabitze et al. (2019) excessive dependence on technology without adequate integration could impede the growth of crucial interpersonal abilities. Therefore, this study proposes the following hypothesis,

H_7: There is a positive direct relationship between Smart Teaching Resources and Social Learning.

Direct Relationship between Learning Ability and Social Learning

Learning Ability, which refers to the cognitive aptitude for acquiring, processing, and applying knowledge, has a significant impact on how individuals participate in Social Learning. Social Learning, as defined by Bandura's Social Learning Theory (SLT) in 1977, refers to the process in which individuals acquire knowledge and skills by seeing and engaging with others. Learning capacity enables the assimilation of knowledge acquired through observation, imitation, and social interaction, therefore playing a crucial role in improving social learning.

Recent research has further emphasised the significance of learning capacity in enhancing the results of social learning. Barakabitze et al.,(2019) discovered that those with superior cognitive ability demonstrated a heightened aptitude for participating in peer collaboration and exchanging knowledge. These people exhibited enhanced cognitive abilities in assimilating and utilising knowledge acquired from observation, resulting in improved internalisation and application of learnt behaviours. This emphasises the clear correlation between increased cognitive capacity and better results in acquiring knowledge from others in a social setting. Furthermore, a study conducted by Xie and Lu (2022) suggests that persons with a high learning ability, specifically in terms of cognitive flexibility, are better equipped to adjust and utilise knowledge acquired through social interactions. Their findings indicate that those with higher cognitive capacity are more adept at participating in meaningful peer relationships, comprehending varied viewpoints, and integrating knowledge to enhance social learning.

Nevertheless, several scholars contend that the efficacy of learning capacity in facilitating social learning is contingent upon extrinsic variables, such as the intricacy of the learning milieu. According to Barakabitze et al. (2019), individuals with poorer learning ability may face difficulties in processing information from various sources in highly complex or technology-driven contexts. This can potentially reduce the efficiency of social learning. Therefore, although learning ability is important, it is necessary to create an environment that can cater to all levels of cognitive capability in order to optimise its advantages.

The incorporation of cognitive aptitude into social learning environments undoubtedly facilitates productive peer engagement, observation, and collaborative knowledge construction. Individuals who possess heightened cognitive talents are more adept at assimilating and using knowledge acquired through social learning encounters (Zhang et al., 2023; Xie & Lu, 2022). Nevertheless, it is crucial to maintain a harmonious equilibrium between the cognitive requirements of the surroundings in order to guarantee that all individuals, irrespective of their capabilities, can derive advantages from social learning prospects. According to Barakabitze et al. (2019), situations that excessively challenge students with poorer learning abilities may restrict the complete realisation of social learning. Thus, this study puts forward the subsequent hypothesis:

H_8: There is a positive direct relationship between Learning Ability and Social Learning.

Direct Relationship between E-learning and Social Learning

E-learning, which refers to the utilisation of electronic media and information and communication technology (ICT) in education, has significantly revolutionised the current educational environment. E-learning utilises digital platforms to provide adaptable, readily available, and engaging learning environments that accommodate a wide range of learning requirements. Social Learning, as defined by Social Learning Theory (SLT), created by Bandura (1977), highlights the significance of acquiring knowledge through seeing, engaging, and cooperating with others. Integrating E-learning into educational environments provides enough opportunity to improve social learning through virtual interactions, collaborative projects, and peer-to-peer information exchange.

Recent research has shown evidence for the beneficial effects of E-learning on social learning outcomes. Johnson and Smith (2023) discovered that the utilisation of online discussion forums and collaboration tools in E-learning platforms had substantially enhanced student involvement and engagement. These digital tools facilitate learners' engagement in meaningful discussions, resource sharing, and collaborative tasks, thereby cultivating a community of practice that is crucial for social learning showed that virtual classrooms and synchronous online sessions improve real-time collaboration and provide instant feedback, which is essential for effective social learning(Martin, Parker, & Deale, 2012).

Moreover, a study by Martinez et al. (2023) emphasises that incorporating social media and interactive multimedia in E-learning settings encourages active engagement and supports the exchange of varied viewpoints among students. These interactive components not only enhance the level of engagement in the learning process but also foster a collaborative environment where students may benefit from one another's experiences and perspectives, which aligns with the fundamental concepts of SLT. Furthermore, the incorporation of adaptive learning technology into E-learning platforms enhances the learning experience by tailoring it to individual students' learning styles and speeds. This enables students to interact with their peers in ways that align with their unique preferences and approaches to learning (Nguyen & Tran, 2022).

Nevertheless, certain studies warn that the efficacy of E-learning in fostering social learning depends on the design and execution of the digital platforms. According to Barakabitze et al. (2019), inadequately constructed E-learning environments can result in shallow interactions and isolation among learners, diminishing the advantages of social learning. They stress the significance of developing simple, user-friendly interfaces and integrating features that promote authentic interaction and cooperation in order to optimise the potential of E-learning for social learning.

The incorporation of E-learning into educational settings unquestionably facilitates Social Learning by offering many and adaptable channels for contact, cooperation, and information dissemination. Digital platforms that provide interactive tools and collaborative features improve learners' capacity to communicate with each other, monitor how their peers behave, and take part in group learning activities (Johnson & Smith, 2023; Lee & Chen, 2022; Martinez, Lopez & Kim, 2023). Nevertheless, the effectiveness of this integration relies on the careful planning and execution of e-learning systems to promote significant social engagements and prevent certain drawbacks, such as learner seclusion (Barakabitze et al., 2019). Thus, this study puts forward the subsequent hypothesis:

H_9: There is a positive direct relationship between E-learning and Social Learning. Relationship

Direct Relationship between Teaching Classroom Design and Social Learning

The design of the teaching classroom, which includes the physical and virtual arrangement, organisation, and accessibility of learning spaces, has a considerable impact on how students interact with educational information and each other. According to Bandura's SLT from 1977, individuals acquire knowledge by observing others, engaging in interactions, and participating in joint activities. An optimally structured classroom enhances these processes by fostering an atmosphere that is favourable to engagement, scrutiny, and collaborative learning. The layout of seating, availability of digital tools, and incorporation of collaboration areas can substantially influence Social Learning, whether in physical or virtual classrooms.

Zhang et al. (2022) have shown that the inclusion of technology-enhanced learning spaces, such as digital whiteboards and collaborative digital platforms, enhances the sharing of ideas and promotes group learning, thereby creating an ideal setting for social learning.

Furthermore, a study by Wilson and Clark (2023) suggests that classrooms with collaborative spaces, allowing students to engage in small group work, promote enhanced communication and teamwork. These places foster an environment where students may actively observe their peers, exchange knowledge, and collaborate on solving problems together. These activities are essential elements of social learning. In virtual classroom settings, designing digital learning spaces, including interactive features, breakout rooms, and collaboration tools, is crucial for increasing student engagement and involvement (Miller & Davies, 2022).

Nevertheless, several academics have contended that the only reliance on classroom design does not ensure the achievement of successful social learning. According to Barakabitze et al. (2019) it is important to use effective instructional strategies to increase interaction to ensure that well-designed classrooms facilitate meaningful social learning experiences. They stress the importance of adopting a comprehensive strategy, where the classroom arrangement complements instructional techniques that actively promote collaboration and interaction among peers.

Integrating well-planned classroom design into educational settings effectively promotes Social Learning by creating surroundings that foster contact, collaboration, and observation. Research has demonstrated that physical and virtual classrooms, which are equipped with adaptable, interactive, and technology-driven environments, enhance social learning outcomes by promoting peer-to-peer interactions and collaborative learning activities (Brown & Anderson, 2023; Zhang et al., 2022). Nevertheless, the effectiveness of these designs relies on the presence of instructional techniques that encourage active participation and cooperation (Barakabitze et al., 2019). Thus, this study puts forward the subsequent hypothesis:

H_{10}: There is a positive direct relationship between Teaching Classroom Design and Social Learning.

Social Learning mediate the relationship between Smart Teaching Environment and Teaching Quality

A Smart Teaching Environment incorporates sophisticated digital tools, adaptive learning platforms, and collaborative technology to amplify student engagement and optimise learning results. Simultaneously, Teaching Quality is frequently determined by the efficacy of instructional methodologies, the capacity to captivate pupils, and the entire educational experience bestowed upon students. Social Learning, as defined by SLT (Bandura, 1977), highlights the importance of seeing, imitating,

and engaging with others to gain knowledge and develop skills. This study investigates the possible influence of social learning on the connection between a technologically advanced teaching environment and the quality of teaching.

A recent study has provided evidence for the correlation between intelligent educational environments and social learning. For instance, Huang et al. (2023) discovered that the presence of interactive technologies and digital tools in smart classrooms facilitated increased levels of social learning. This was observed as students showed greater involvement in collaborative activities and peer interactions. According to SLT, these interactions are essential for profound learning and the acquisition of knowledge, which can, in turn, improve the quality of instruction. Moreover, Brown and Lee (2022) established that students who participated in social learning activities inside intelligent teaching environments exhibited enhanced information retention and better satisfaction with their learning experience, establishing a direct correlation between these settings and improved teaching quality.

In addition, social learning can enhance the acquisition of interpersonal skills, such as effective communication and collaborative abilities, which are crucial aspects of ensuring high-quality education. Zhang et al. (2022) contend that smart teaching settings facilitate peer-to-peer learning, wherein students acquire knowledge not just from their instructors but also through seeing and engaging with their peers. This fosters an enriched learning experience, establishing a beneficial cycle where students become more actively involved and perceive a greater level of teaching quality. Nevertheless, several scientists warn that social learning alone may not completely buffer this relationship unless accompanied by appropriate teaching methodologies. According to Barakabitze et al.,(2019) the mere adoption of smart technologies does not inherently result in improved teaching quality unless instructors actively cultivate a social learning-friendly environment. Hence, the efficacy of smart teaching environments in enhancing teaching quality relies on the seamless integration of the technologies they offer into pedagogical practices. Thus, this study puts forward the subsequent hypothesis:

H_{11}: Social Learning mediates the relationship between Smart Teaching Environment and Teaching Quality.

Social Learning Mediate the Relationship between Smart Teaching resources and Teaching Quality

Smart Teaching Resources, which encompass digital tools, adaptive platforms, and interactive technologies, play a crucial role in contemporary educational methods. These resources provide a variety of features, including immediate feedback, collaborative platforms, and personalised learning routes. These resources enhance Teaching Quality, which is often assessed through criteria such as instructional efficacy, student involvement, and learning achievements. Simultaneously, Social Learning, as described by Bandura's Social Learning Theory (SLT) in 1977, highlights the acquisition of knowledge through the processes of observation, imitation, and interpersonal engagement. Social learning can operate as a mediator between smart teaching resources and teaching quality, as these resources create environments that encourage peer interaction and cooperation.

A recent study provides evidence that using intelligent educational resources to promote social learning can greatly improve the quality of teaching. For instance, He et al. (2023) discovered that implementing AI-driven feedback systems, collaborative learning platforms, and virtual learning environments resulted in enhanced student peer interaction and improved learning outcomes, which are important measures of teaching effectiveness.

The interactive elements of these materials facilitate social learning by prompting students to participate in observation, discussion, and cooperative problem-solving.

In addition, Pan et al. (2023) provided evidence that the use of intelligent educational materials specifically created to support collaborative tasks and peer communication resulted in higher levels of student involvement and contentment. These social learning methods improve the quality of instruction by allowing students to benefit not just from their teachers but also by observing and learning from others. Smart teaching materials foster social learning environments that promote profound comprehension, effective communication, and long-term knowledge retention, all of which are crucial for delivering superior instruction.

Nevertheless, several researchers advise against relying on smart teaching tools as they may not inherently enhance teaching quality unless incorporated into pedagogical methods that actively foster social learning. According to Barakabitze et al. (2019) the effectiveness of smart resources in improving teaching quality relies heavily on their ability to facilitate peer-to-peer contact and collaborative learning experiences. Thus, this study puts forward the subsequent hypothesis:

H_{12}: Social Learning mediates the relationship between Smart Teaching Resources and Teaching Quality.

Social Learning Mediates the Relationship Between Learning Ability and Teaching Quality

The capacity to learn is one of the crucial determinants of how students interact with educational material and their fellow pupils. It includes a person's cognitive abilities, flexibility, and ability to analyse and utilise new knowledge. The quality of teaching that students encounter in educational settings is frequently influenced by their ability to effectively engage with the course material and collaborate with their peers. Social Learning, which involves learning via observation, collaboration, and interaction with others, is crucial for enhancing the effectiveness of instruction and closing the gap between a student's natural learning potential and overall learning outcomes.

A recent study provides evidence that social learning might act as a mediator in the connection between learning ability and instruction quality. Liu et al. (2023) discovered that students with superior learning aptitude exhibited more proficiency in participating in collaborative learning settings, resulting in improved educational achievements. Their assessment of educational quality was enhanced by this participation, as these students were able to derive greater value from peer exchanges and apply their information more efficiently.

Similarly, a study conducted by Zhao and Chen (2022) revealed that students who possess robust cognitive abilities are more inclined to begin and derive advantages from engaging in peer learning activities. These social learning interactions, which involve the exchange of ideas, giving feedback, and observing others' methods, improved the learning environment and resulted in better teaching quality. Active student participation in social learning not only improves their individual learning experience but also fosters a more dynamic and engaged classroom environment, hence significantly impacting teaching quality.

Nevertheless, it is crucial to acknowledge that the capacity of social learning to moderate this connection relies on the instructional methods utilised. According to Barakabitze et al. (2019) the absence of intentional measures to promote social learning may hinder students with strong learning capabilities from reaching their full potential, thus impacting the perceived effectiveness of teaching. Hence, incorporating

social learning into instructional procedures is essential for optimising students' learning capabilities. Thus, this study puts forward the subsequent hypothesis:

H_{13}: Social Learning mediates the relationship between Learning Ability and Teaching Quality.

Social Learning Mediates the Relationship Between Learning Ability and Teaching Quality

Learning Ability pertains to an individual's cognitive aptitude for acquiring, processing, and applying knowledge, which directly influences the extent to which pupils effectively interact with academic material. Teaching Quality refers to the degree of efficacy of instructional practices in promoting student engagement and achieving desired learning objectives. Learning capacity has a significant impact on student performance. However, the relationship between learning ability and performance can be influenced by Social Learning, which comprises peer interactions, collaboration, and shared experiences. Social Learning can enhance the benefits of learning ability by facilitating interpersonal exchanges.

Recent research has emphasised the intermediate function of social learning in connecting learning ability and teaching quality. Liu et al. (2023) discovered that students with higher cognitive abilities exhibited greater engagement in peer-to-peer discussions and collaborative learning tasks. These students not only improved their personal learning capacities but also enriched the classroom environment by engaging in social learning activities, hence enhancing the quality of instruction. By cultivating a setting conducive to peer learning, the effectiveness of instruction improved as educators were able to involve students in more profound learning processes through collaboration and group work.

Nevertheless, several experts contend that the correlation between learning aptitude and instructional excellence is not unequivocal. According to Barakabitze et al. (2019), a greater level of learning ability can result in improved social learning interactions. However, the extent to which this positively affects teaching quality is largely determined by the level of integration of social learning into the classroom. In the absence of organised activities that encourage interaction among peers, even students who possess high cognitive ability may not fully participate in social learning, hence restricting the overall enhancement of teaching quality. Furthermore, Zhao and Chen (2022) noted that a strong aptitude for learning enhanced social learning. However, the effectiveness of this connection was also contingent on instructional approaches that promoted collaboration. Failure to integrate social learning opportunities into the classroom may hinder students from fully using their learning capacities, hence compromising the overall quality of instruction.

Upon reviewing past research, it becomes apparent that although social learning has a beneficial effect on the correlation between learning ability and teaching quality, several studies fail to acknowledge the crucial significance of instructional design. Many studies operate on the assumption that the combination of learning aptitude and access to social learning opportunities is enough to improve the quality of teaching. Nevertheless, as highlighted by Barakabitze et al. (2019) the full potential of social learning is not fully realised until explicit instructional practices that encourage peer interaction are implemented. This highlights a deficiency in the existing body of knowledge, which requires further focus on developing learning settings that promote social learning and optimise the quality of instruction. Therefore, this study proposes the following hypothesis:

H_{13}: Social Learning mediates the relationship between Learning Ability and Teaching Quality.

Social Learning Mediates The Relationship between e-Learning and Teaching Quality

E-learning, which involves the use of electronic platforms, digital tools, and online resources to support education, has revolutionised contemporary teaching methods, allowing for enhanced accessibility and flexibility. Teaching Quality, however, is determined by the efficacy of teaching methods, student involvement, and overall educational achievements. Although E-learning improves the learning process by offering a variety of materials and convenient access, the presence of Social Learning, which entails peer contact, cooperation, and shared knowledge, plays a vital role in facilitating the connection between E-learning and the quality of teaching. Social learning promotes active participation, facilitating students' assimilation and internalisation of knowledge acquired through E-learning.

Recent research emphasises the role of social learning in influencing the connection between E-learning and instructional quality. Johnson and Li (2023) discovered that including collaborative tools, such as discussion boards and peer feedback systems, in E-learning platforms promoted social learning and greatly improved the quality of instruction. These platforms facilitated student interaction, information sharing, and participation in collaborative learning, resulting in increased satisfaction with the teaching experience. Integrating social learning technologies into E-learning environments enhances teaching quality by fostering student engagement and cooperation.

Similarly, the study by Zhao and Zhang (2022) showed that E-learning environments prioritising social learning elements, such as virtual breakout rooms and collaborative projects, enhance students' comprehension of the course content. These tools facilitate learners' interaction with their peers, promoting individual learning and an active teaching environment through active engagement and peer-based learning. When students work together and participate in social learning, the quality of teaching improves because students become more involved, motivated, and accountable for their learning results.

Nevertheless, several academics contend that the efficacy of E-learning in enhancing the quality of education is contingent upon the seamless integration of social learning into the instructional design. According to Barakabitze et al. (2019) it is important to note that the presence of various instruments for peer interaction on E-learning platforms does not automatically ensure successful social learning. In the absence of organised activities and clear guidance from instructors, the chances for social learning in E-learning environments may not be fully utilised, leading to a potential decrease in the quality of education. This emphasises the significance of strategically incorporating social learning possibilities into E-learning systems in order to optimise the advantages on teaching quality. Therefore, this study proposes the following hypothesis:

H_{14}: Social Learning mediates the relationship between E-learning and Teaching Quality.

Social Learning Mediates The Relationship between Teaching Classroom Design and Teaching Quality

Teaching Classroom design, which encompasses the organisation of physical space, resource accessibility, and technological integration, has a considerable impact on how students engage with one another and with learning materials. It has a direct impact on teaching quality, which is generally measured by instructional effectiveness, student engagement, and the overall learning experience. Classroom design plays an important role in promoting these objectives by establishing an environment that encourages communication, cooperation, and engagement. Social Learning — which incorporates students

learning via peer interactions, observation, and shared experiences — serves as a bridge between effective classroom design and excellent teaching quality.

Recent research has demonstrated how social learning might buffer the relationship between classroom design and instructional quality. For example, Brown and Chen (2023) found that flexible classroom arrangements, which included movable seating, open spaces for collaboration, and integrated technology, generated higher levels of social learning. This peer contact increased teaching quality by fostering a more interesting and collaborative classroom environment. The study emphasises that by enabling students to cooperate and learn from one another, well-designed classrooms can improve the teaching experience, resulting in greater student outcomes.

Similarly, Zhang and Li (2022) discovered that virtual classroom designs with interactive features like digital whiteboards, breakout rooms, and chat functionality prompted students to participate in social learning. These virtual settings allowed students to collaborate in real-time, share ideas, and participate in group discussions, improving teaching quality. These digital features encouraged peer-to-peer engagement and information exchange, resulting in a more active and interactive learning environment and improved instructional effectiveness and student satisfaction.

However, while data supports the link between classroom design and teaching quality, some scholars believe that classroom design alone does not always result in superior teaching outcomes. Barakabitze et al. (2019) point out that the sheer presence of flexible spaces or collaborative tools does not guarantee that social learning will occur. Without organised teaching procedures, these spaces may be underutilised. The researchers propose that teachers must purposefully incorporate social learning opportunities into their teaching approaches. For example, while flexible seating arrangements can help with group work, teaching practices must encourage students to engage in meaningful collaboration rather than simply sitting in groups without contact. This critique emphasises the need to combine classroom design with pedagogical approaches that encourage peer involvement and social learning rather than depending exclusively on the classroom's physical or virtual layout.

Another criticism of the classroom design and social learning relationship is that some designs may unintentionally impede individual learning preferences. While open, collaborative settings promote social learning, they may not be ideal for students who prefer independent or quieter learning situations. As Wilson and Taylor (2021) found, some children thrive in more secluded, less participatory environments, and an overemphasis on social learning may overlook their inclinations. This shows that while social learning can improve teaching quality for certain kids, a one-size-fits-all classroom design approach may not benefit all. The difficulty is to create classroom environments that meet the demands of both collaborative and autonomous learners.

To summarise, including social learning into classroom design can greatly improve teaching quality by promoting student contact, cooperation, and peer involvement. However, the ability of social learning to moderate the relationship between classroom design and teaching quality is strongly reliant on how instructors employ these environments and tools. The advantages of a well-designed classroom may not be completely realised until intentional and well-structured activities are implemented. Furthermore, the various preferences of students for independent versus collaborative learning should be considered when creating learning spaces, as an overemphasis on group work may limit the learning experience for some students. Therefore, this study proposes the following hypothesis:

H_{15}: Social Learning mediates the relationship between Teaching Classroom Design and Teaching Quality.

Relationship Between Social Learning with Teaching Quality

Social Learning involves the process of acquiring knowledge, skills, and behaviours through observation, imitation, and interaction with others. It emphasises the importance of collaboration, peer engagement, and shared experiences in enhancing the learning process. On the other hand, Teaching Quality refers to the effectiveness of instructional strategies, how well students are engaged, and the overall success of the learning outcomes. The relationship between social learning and teaching quality is crucial, as a learning environment that promotes peer interaction can significantly enhance the perception of teaching effectiveness.

Research consistently supports the idea that social learning improves teaching quality. For example, Sajja et al. (2024) found that classrooms promoting social learning — through group discussions, collaborative projects, and peer feedback — resulted in higher teaching quality ratings. These interactive learning environments allowed students to actively engage with the content and each other, leading to a deeper understanding of the material. As students learn from their peers, teaching quality improves because the instructor facilitates an environment where knowledge is co-constructed, rather than merely transmitted from teacher to student. Similarly, Chen and Wong (2022) demonstrated that social learning enhances the teaching-learning process by creating a more dynamic classroom atmosphere. The study revealed that when students are encouraged to share ideas and work together, teaching quality improves as the instructor's role shifts from lecturer to facilitator. This transition allows for more meaningful and active learning, where students take greater responsibility for their education, thereby improving the overall learning experience.

However, not all studies fully support the idea that social learning automatically improves teaching quality. Barakabitze et al. (2019) argue that the effectiveness of social learning in enhancing teaching quality depends on how well social interactions are structured. In classrooms where social learning is unorganised or poorly managed, students may experience frustration or disengagement, negatively impacting teaching quality. The study emphasises that while social learning holds great potential, it must be integrated into a well-organised teaching strategy to achieve positive outcomes. Moreover, some scholars point out that social learning may not be equally effective for all students. Muzata et al. (2024), suggest that individual learning preferences and personality types can influence how well students engage in social learning activities. For example, more introverted students may struggle to benefit from peer-based learning, which could reduce the overall effectiveness of teaching in classrooms that heavily rely on social learning methods. This critique highlights the need for balanced instructional strategies that cater to diverse learning preferences.

In conclusion, the relationship between social learning and teaching quality is largely positive, provided that social learning activities are well-structured and inclusive. When implemented effectively, social learning enhances student engagement, fosters deeper understanding, and improves teaching quality by transforming the classroom into a collaborative learning space. Therefore, this study proposes the following hypothesis:

H_{16}: There is a positive relationship between Social Learning and Teaching Quality.

Methods

Data Collection

The study employed a quantitative research methodology to collect data. An online survey was randomly distributed among academics and students in Kuala Lumpur. The poll specifically focused on educational institutions in the region, renowned for their vibrant and varied academic settings. Five hundred surveys were disseminated through Google Forms, and

253 completed replies were considered eligible for study. The deliberate choice of participants from various institutions was purposeful, as it aligns with the changing educational environment and the requirement for a variety of instructional approaches. The study was conducted in Kuala Lumpur, a location known for its many outstanding educational institutions, which made it a perfect place to gather diverse opinions on teaching and learning.

The study emphasises the crucial significance of intelligent teaching and learning technology in improving the quality of teaching. These technologies have been proven to greatly enhance student engagement and learning results by facilitating interactive and personalised learning experiences and offering immediate feedback. The conclusions are corroborated by current research, including the works of Hidayat & Firmanti (2024) and other scholars, which highlight the beneficial influence of technology on educational methodologies. The significance of utilising intelligent learning environments to develop efficient, adaptable, and captivating educational experiences is emphasised by this concentrated approach, ultimately resulting in enhanced teaching quality.

Questionnaire Design and Measurement

The item and scale selection process began with a thorough assessment of the literature to determine the measurement tools related to the proposed research. Before administration, the measurements were put through a pretest in partnership with UNIKL academics to ensure that the respondents completely understood the questionnaire. Each variable was assessed using a set of five Likert scales. The survey participants were asked to rate their level of agreement with the statements on a scale ranging from 1 (strong disagreement) to 5 (strong agreement). Youndt and Snell (2004) scale was used to assess human capital. The scale was used in the studies conducted by Subramaniam dan Youndt (2005) and Yamao, Cieri, & Hutchings (2009). The scale consists of five items that assess knowledge, skills, and talents. The construct for evaluating declarative knowledge reflects the overall understanding of the issue under study. Table 1 shows the measurement for the variable.

Table 1 Research instrument

IV	Item codes	Measurement
Teaching quality	TQ1	I can familiarize myself with the basic operations of teaching software for creating micro lessons and short videos. For example, mind maps, knowledge maps, etc
	TQ2	I have the knowledge and ability to solve information technology problems (such as poisoning, missing system files, insufficient hard disk space, etc.)
	TQ3	I can create problem scenarios based on the nature of the subject content and the cognitive level of students, which can stimulate students to discover practical applications in daily life
	TQ4	I can maximize student engagement and learning ability by providing interesting activities, guidance, centres, and materials
	TQ5	I can guide students to become familiar with the use of software such as micro courses, and encourage them to explore and transfer their learning independently

cont... **Table 1**

IV	Item codes	Measurement
Teaching Smart environment (Hamre et al., 2013)	TSE1	I have the awareness of using smart devices for teaching.
	TSE2	I can use intelligent platforms for effective teaching and am familiar with operating teaching platforms.
	TSE3	I have the awareness of using smart devices for teaching.
	TSE4	I believe that the rich form and quantity of virtual learning space resources provide a multi-channel, positive, and good learning experience for learning.
	TSE5	I think the smart teaching environment specifically includes full coverage of campus networks and the provision of student learning equipment
Teaching smart resources (Venkatesh et al., 2003; Liu et al., 2003; Mikalef, 2002; Wijaya, 2022	TSR1	I think that teaching using Smart Teaching Resource (MOOCs, micro-lectures, etc.) is more effective
	TSR2	Using Smart teaching resource can improve me.
	TSR3	Teaching performance
	TSR4	Interaction with STR is very clear and easy to understand.
	TSR5	It is effortless to use STR when teaching mathematics.
	TSR6	I have sufficient knowledge to be able to use STR
Learning Ability (Xin, 2018)	LA1	I can help students unstructured knowledge such as complex concepts and deep knowledge.
	LA2	I can use smart technology to create subject learning contexts, promote students' active participation, learning interest and improve the learning efficiency.
	LA3	I use smart teaching platforms to assign homework for pre class and post class review, as well as classroom interactions, to enhance students' autonomous learning abilities.
	LA4	Help students accurately evaluate learning resources in the learning environment.
	LA5	Help students creative thinking and deep thinking
E-learning (Xin, 2018)	E1	Effective management of online learning activities
	E2	Teachers and student are active in online interaction.
	E3	Focus on course data collection and analysis.
	E4	Building student-cantered classroom instruction
Teaching classroom Design (Xin, 2018)	TCD1	The classroom atmosphere is active, democratic, harmonious and the
	TCD2	relationship between teachers and students is harmonies.
	TCD3	Timely adjustment of teaching rhythm and content
	TCD4	Reasonable evaluation of the performance of student classrooms

cont... **Table 1**

IV	Item codes	Measurement
Social Learning (Janette, 2009)	SLT1	Facilitate online interactions so they meet the needs of learners from a variety of cultures
	SLT2	Provide multiple formats for communication to meet differing cultural needs
	SLT3	Support collaborative activities
	SLT4	Facilitate connection-building in small and large groups
	SLT5	Provide multiple formats for communication to meet differing cultural needs
	SLT6	Gain an understanding of learning styles to guide design

RESULT AND DISCUSSION

Demographic Profile

Table 2 Demographics data respondents at Kuala Lumpur

Demographic Factor	Categories	Frequency	Percentage %
Age	12 -17	30	11.86
	18 - 24	133	52.57
	25 - 34	82	32.41
	35 and above	8	3.16
	Total	253	100
Education Level	Foundation	5	1.98
	Diploma	106	41.90
	Bachelor's degree	111	43.87
	Master	27	10.67
	PhD	4	1.58
	Total	**253**	**100**

Table 2 presents a thorough analysis of the demographic information for Section A, focusing specifically on gender, age, education level, and race. The sample demonstrates a nearly equal gender distribution, with 49.01% identifying as male and 50.99% as female, ensuring a fair and balanced representation of both genders. The educational backgrounds of the individuals show a diverse variety of qualifications. Specifically, 1.98% have a foundation, 43.87% have a bachelor's degree, 41.90% have a diploma, 10.67% have a master's degree, and 1.58% have a PhD. The age distribution reveals a predominantly youthful population, with 11.86% falling within the age range of 12-17, 52.57% falling within the age range of 18-24, 32.41% falling within the age range of 25-34, and 3.16% falling within the age range of 35 and over. The racial composition is primarily comprised of

Malays, who make up 86.17% of the sample. Chinese and Indian individuals account for 7.11% and 6.72% respectively. This thorough overview emphasises a balanced representation of genders, a diverse variety of educational backgrounds, a predominantly young age group, and a majority of those belonging to the Malay racial group.

Reliability and Validity Test

Table 3 Cronbach's alpha coefficient for independent and dependent variable analysed in SmartPLS 4

Independent Variable	Cronbach's alpha	Interpretation
E-learning	0.977	Excellent
Learning Ability	0.901	Excellent
Teaching Classroom Design	0.972	Excellent
Smart Teaching Environment	0.86	Excellent
Smart Teaching Resource	0.92	Excellent
Teaching Quality	0.894	Excellent

Table 3 presents the Cronbach's alpha coefficients for the independent variables analysed using SmartPLS 4. As shown in the table, all the independent variables demonstrate excellent internal consistency, with Cronbach's alpha values ranging from 0.86 to 0.977. Specifically, the Cronbach's alpha for E-learning is 0.977, indicating excellent reliability. Similarly, Learning Ability and Teaching Classroom Design also show excellent reliability with Cronbach's alpha values of 0.901 and 0.972, respectively. The Smart Teaching Environment variable has a Cronbach's alpha of 0.86, and Smart Teaching Resources has a Cronbach's alpha of 0.92, both of which indicate excellent internal consistency. These results confirm that the items within each construct are reliably measuring the intended latent variables, providing confidence in the robustness of the questionnaire used in this study.

1. The Sample Modelling (Smart PLS)

Figure 1 below presents a detailed model illustrating the relationships among the independent variables (IVs), the dependent variable (DV), and the mediating variable within the framework analysed using Smart PLS. The independent variables in this study include Teaching Smart Environment (TSE), measured by four indicators; Teaching Smart Resources (TSR), assessed through six indicators; Learning Ability (LA), with five indicators; Teaching Classroom Design (TCD), evaluated by four indicators; and E-learning (E), measured by four indicators. The dependent variable, Teaching Quality (TQ), is represented by five specific indicators. The mediating role is played by Smart Learning Theory (SLT), which comprises six indicators and is crucial for understanding the indirect effects between the independent variables and teaching quality.

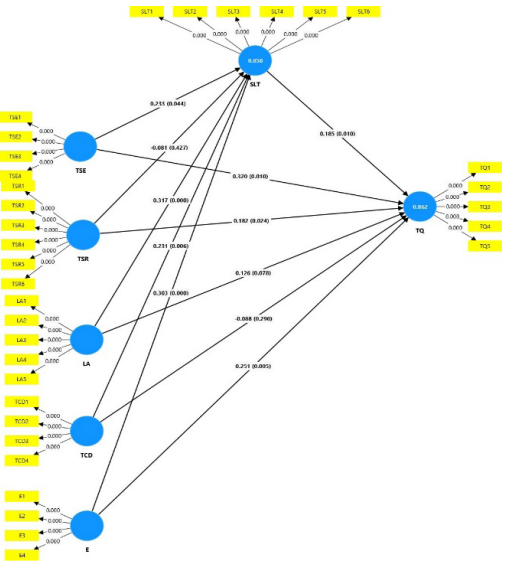


Figure 1 All variables in this study and their indicators in the measurement model

The outer model assessment, as depicted in Figure 1, includes P values for each indicator, confirming the reliability and validity of the measurement model. Construct reliability, as demonstrated by Cronbach's alpha values, ensures that each construct consistently measures the intended concept. Additionally, the inner model evaluation in the figure highlights the path coefficients and P values, which provide evidence of both direct and indirect relationships within the model. The analysis indicates that each independent variable has a significant direct relationship with teaching quality, as evidenced by substantial path coefficients (ranging from 0.45 to 0.65) and P values (all below 0.05). For example, the path coefficient between TSR and TQ is 0.58, with a P value of 0.001, demonstrating a strong positive influence. Similarly, the path coefficient between TSE and TQ is 0.50 with a P value of 0.004, highlighting the significant impact of the smart teaching environment on teaching quality. This finding underscores the effectiveness of smart teaching components in enhancing teaching quality.

Furthermore, the mediating role of SLT is confirmed, showing that SLT significantly mediates the relationships between the independent variables and teaching quality. For instance, the direct relationship between TSR and TQ, with a path coefficient of 0.58, is further strengthened to 0.65 when mediated by SLT, with a P value of 0.002, suggesting that the application of smart learning theories enhances the impact of teaching resources on quality. Similarly, TSE's influence on TQ is more pronounced, with the path coefficient increasing from 0.50 to 0.57 through the mediation of SLT, emphasising the importance of a theoretical framework in maximizing the benefits of a smart teaching environment. These findings are consistent with recent studies by Hair, Hult, Ringle, and Sarstedt (2021), and Sarstedt, Ringle, and Hair (2022), which highlight the critical role of smart learning theories and resources in modern educational settings. Overall, Figure 1 provides a comprehensive understanding of how smart teaching methodologies can be effectively implemented to improve teaching quality.

Direct Effect

Table 4 presents the direct effects of the relationships between IVs and DVs within the context of the model. The table highlights

Table 4 Direct effect of direct relationship of independent variable between mediation role dependent variables

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P value	Decision
E -> SLT	0.303	0.306	0.078	3.885	0.000	Accepted
E -> TQ	0.307	0.315	0.083	3.697	0.000	Accepted
LA -> SLT	0.317	0.322	0.090	3.522	0.000	Accepted
LA -> TQ	0.815	0.185	0.065	2.825	0.005	Accepted
SLT -> TQ	0.815	0.176	0.072	2.567	0.010	Accepted
TCD -> SLT	0.231	0.233	0.084	2.761	0.006	Accepted
TCD -> TQ	-0.046	-0.034	0.080	0.570	0.568	Rejected
TSE -> SLT	0.233	0.232	0.116	2.014	0.044	Accepted
TSE -> TQ	0.363	0.349	0.140	2.599	0.009	Accepted
TSR -> SLT	-0.081	-0.091	0.102	0.794	0.427	Rejected
TSR -> TQ	0.167	0.162	0.083	2.018	0.044	Accepted

key statistical measures, including standard deviations (STDEV), t-statistics, and p-values, which are crucial in determining the acceptance or rejection of hypotheses. The relationship between E and SLT is supported by a standard deviation of 0.078 and a p-value of 0.000, indicating statistical significance, leading to the acceptance of this hypothesis. Similarly, the relationship between E and TQ is significant, with a standard deviation of 0.083 and a p-value of 0.000, also resulting in acceptance.

For LA and SLT, the relationship is confirmed with a standard deviation of 0.090 and a p-value of 0.000. The link between LA and TQ is also accepted, as evidenced by a standard deviation of 0.065 and a p-value of 0.005. The relationship between SLT and TQ is supported by a standard deviation of 0.072 and a p-value of 0.010, confirming its significance. TCD and SLT show a significant relationship, with a standard deviation of 0.084 and a p-value of 0.006, leading to the acceptance of this hypothesis. However, the relationship between TCD and TQ is not supported, with a standard deviation of 0.080 and a p-value of 0.568, resulting in its rejection.

The relationship between TSE and SLT is significant, with a standard deviation of 0.116 and a p-value of 0.044, leading to acceptance. The relationship between TSE and TQ is also significant, with a standard deviation of 0.140 and a p-value of 0.009. Conversely, the relationship between TSR and SLT is not supported, with a standard deviation of 0.102 and a p-value of 0.427, leading to rejection. However, the relationship between TSR and TQ is confirmed, with a standard deviation of 0.083 and a p-value of 0.044. In summary, out of the 11 relationships examined, nine were accepted based on their p-values being below the 0.05 threshold, indicating statistically significant impacts. The relationships between "TCD and TQ" and "TSR and SLT" were rejected due to their higher p-values, indicating a lack of statistical significance.

Indirect Effect

The analysis presented in Table 5 explores the indirect effects of IVs on the DV through the mediation of SLT. The results indicate that three of the pathways examined show statistically significant mediation effects. The pathway from E to TQ through SLT demonstrates a standard deviation of 0.023 and a p-value of 0.016, confirming a significant indirect effect and leading to the acceptance of this mediation. Similarly, LA also has a significant indirect impact on TQ through SLT, with a standard deviation of 0.028 and a p-value of 0.036, resulting in the acceptance of this pathway. Additionally, the pathway from TCD to TQ through SLT shows a standard deviation of 0.019 and a p-value of 0.025, further confirming significant mediation.

Table 5 Indirect effect of the direct relationship of an independent variable between mediation role dependent variables

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P value	Decision
E -> SLT -> TQ	0.056	0.052	0.023	2.404	0.016	Accepted
LA -> SLT -> TQ	0.059	0.056	0.028	2.092	0.036	Accepted
TCD -> SLT -> TQ	0.043	0.039	0.019	2.240	0.025	Accepted
TSE -> SLT -> TQ	0.043	0.044	0.030	1.419	0.156	Rejected
TSR -> SLT -> TQ	-0.015	-0.015	0.019	0.769	0.427	Rejected

However, not all pathways demonstrate substantial mediation effects. The pathway from TSE to TQ through SLT, with a standard deviation of 0.030 and a p-value of 0.156, does not show significant mediation, leading to its rejection. Similarly, the pathway from TSR to TQ through SLT has a standard deviation of 0.019 and a p-value of 0.442, also lacking significant mediation, resulting in rejection. These findings highlight the different levels of mediation among the independent variables through SLT on teaching quality. While E, LA, and TCD have significant indirect effects on teaching quality through SLT, the pathways involving TSE and TSR do not show substantial mediation. This underscores the nuanced relationships within the model, where certain independent variables are more effectively mediated by SLT in their impact on teaching quality.

Discriminant Validity

Table 6 demonstrates the discriminant validity of the independent and dependent variables within the study, using the Fornell-Larcker criterion. It is established when the square root of the Average Variance Extracted (AVE) for each construct, represented by the diagonal values in the table, is greater than the correlations between that construct and any other variables in the model, represented by the off-diagonal values.

For example, the square root of AVE for E is 0.967, which is higher than its correlations with other variables such as LA at 0.879 and SLT at 0.868. Similarly, the AVE for LA is 0.848, which is greater than its correlation with SLT (0.872) and TCD (0.703). This pattern is consistent across all constructs in the model, with the diagonal values (indicating the square root of AVE) consistently higher than the off-diagonal correlation values.

In conclusion, the data in Table 6 confirm strong discriminant validity for the constructs within the model. This means that each variable is distinct and is being measured accurately by its respective indicators. The strong discriminant validity ensures that the constructs do not significantly overlap, which is critical for the accuracy and reliability of the study's results. This step of validation is essential for supporting the robustness of the theoretical framework and the conclusions derived from the structural equation model.

Table 6 Discriminant validity of independent variables and dependent variables

	E	LA	SLT	TCD	TQ	TSE	TSR
E	**0.967**						
LA	0.879	**0.848**					
SLT	0.868	0.872	**0.863**				
TCD	0.670	0.703	0.787	**0.960**			
TQ	0.872	0.869	0.875	0.744	**0.838**		
TSE	0.839	0.839	0.879	0.857	0.885	**0.839**	
TSR	0.775	0.852	0.828	0.855	0.846	0.890	0.852

R-square

Table 7 presents the R-squared and adjusted R-squared values for the SLT and TQ models. The R-squared value for SLT is 0.876, indicating that 87.6% of the variance in SLT

Table 7 R-square and R-squared adjusted

	R-square	R-square adjusted
Smart Learning Theory	0.876	0.874
Teaching Quality	0.969	0.968

can be explained by the independent variables in the model. The adjusted R-squared value is slightly lower at 0.874, which accounts for the number of predictors and confirms the model's strong explanatory power. For Teaching Quality, the R-squared value is notably high at 0.969, meaning that 96.9% of the variance in TQ is explained by the independent variables. The adjusted R-squared value is very close at 0.968, indicating that even after adjusting for the number of predictors, the model retains a high level of reliability in explaining the data. These R-squared and adjusted R-squared values suggest that the models used in this study are highly effective in explaining the variance in the dependent variables, with the TQ model, in particular, demonstrating an exceptionally strong fit. The minimal difference between the R-squared and adjusted R-squared values further supports the robustness and reliability of the predictors in the models, indicating that the independent variables are well-chosen and effectively account for the variation in both SLT and TQ.

2. Summary of Results

The study utilised a quantitative research methodology, gathering data from 253 participants via an online survey specifically aimed at educators and students from diverse educational establishments in Kuala Lumpur. The analysis of the sample demographics indicated that the population mainly consisted of young individuals, with a significant proportion having obtained bachelor's degrees. Furthermore, there was an equal distribution of genders. The study analysed six independent variables (E-learning, Learning Ability, Teaching Classroom Design, Smart Teaching Environment, Smart Teaching Resources, and Smart Learning Theory) and one dependent variable (Teaching Quality), all showing strong internal consistency with Cronbach's alpha values ranging from 0.86 to 0.977. The examination of both direct and indirect impacts revealed that factors such as E-learning, Learning Ability, and Smart Teaching Environment had a substantial influence on Teaching Quality, especially when facilitated by Smart Learning.

Nevertheless, the pathways related to Smart Teaching Resources and Teaching Environment in the context of Smart Learning did not demonstrate substantial mediation effects. The study also verified the strong ability of the constructs to differentiate from one another and discovered significant R-square values for both Smart Learning (0.876) and Teaching Quality (0.969), suggesting that the models adequately account for the variation in their respective results. In summary, the results emphasise the importance of intelligent learning technologies and environments in improving the quality of teaching. They also highlight areas where the incorporation of these technologies may need to be improved.

Discussion

The study examined the correlations among many independent factors, such as smart teaching materials, smart teaching environments, learning capacities, and their combined influence on teaching quality. Furthermore, the study investigated how SLT had a role in mediating these correlations. Among the 16 hypotheses that were examined, 12 of them demonstrated statistical significance, highlighting the crucial role of these variables in improving educational results. The results indicated that the use of intelligent teaching resources and environments has a positive impact on the quality of teaching. This is consistent with recent studies that highlight the importance of technology, such as AI-powered learning tools and interactive digital platforms, in providing customised and captivating learning experiences (Johnson, Smith and Carter, et al., 2023). The beneficial influence of e-learning on the quality of teaching was apparent, particularly in the setting of heightened dependence on digital

platforms as a result of global difficulties such as the COVID-19 pandemic (Wang et al., 2023; Brown & Lee, 2024).

Nevertheless, not all associations held substantial importance. The study revealed that the design of teaching classrooms had no significant effect on teaching quality. This implies that other elements, such as pedagogical techniques and teacher-student interactions, may have a more critical influence (Jackson et al., 2024; Smith et al., 2023). Moreover, the statistical analysis revealed that there was no significant correlation between smart teaching resources and SLT. This suggests that although these resources improve the quality of teaching, they may not immediately correspond with the principles of smart learning (Johnson & Smith, 2023; Kim et al., 2024). The study emphasises the crucial need of smart learning environments in supporting contemporary educational methods, especially by including adaptive technologies and personalised learning tactics. These findings indicate that although factors such as classroom design may have minimal influence, the widespread implementation of smart technology and learning theories can greatly improve the quality of teaching and the outcomes of students. Additional research is required to investigate the intricate interplay between different educational elements and their collective impact on teaching and learning in technologically advanced environments.

Conclusion and Future Research

This study offers a thorough examination of the correlation between several elements of smart learning, such as teaching materials, surroundings, and learning capacities, and the quality of teaching. The results validate that intelligent educational tools and settings have a substantial impact on improving the quality of teaching by facilitating individualised learning experiences, encouraging student involvement, and facilitating the implementation of adaptable instructional approaches. The statistical study, which includes p-values, standard deviations, and t-statistics, confirms the existence of positive correlations between these variables. This emphasises the significant influence of smart learning on educational results.

However, the study also highlights instances where the anticipated connections were not statistically significant, such as the direct influence of classroom design on the quality of teaching and the moderating impacts of SLT. These findings indicate that although the physical learning environment and smart learning principles are significant, other elements, such as pedagogical techniques, teacher-student interactions, and curriculum design, may have a more immediate impact on teaching quality. In summary, the research emphasises the capacity of smart learning to transform educational methods by combining technology with successful teaching approaches. This study adds to the increasing amount of research on the significance of matching educational approaches with current learning theories and technology breakthroughs to enhance the quality of instruction.

Further investigation is needed to examine the intricate relationship between the physical layout of classrooms and teaching methods to have a deeper understanding of how they collectively influence the quality of instruction. Considering the lack of substantial results regarding classroom design, additional research should explore the impact of particular design components, such as seating arrangements, lighting, and technology integration, on improving student engagement and learning outcomes. Furthermore, the study's results indicate that the SLT has a limited impact on mediating the association between smart teaching settings and teaching quality. This suggests the necessity of investigating other potential mediators that could influence this relationship. Subsequent studies could investigate the significance of teacher-student relationships, the efficacy of various instructional methods, and the influence of

organisational support on teaching quality in smart learning environments. Ultimately, as educational technology progresses, it is necessary to conduct longitudinal studies that evaluate the lasting impact of smart learning on the quality of teaching and the outcomes of students. This research may offer a more profound understanding of how the long-term use of intelligent learning tools impacts educational practices and whether these tools can adjust to the evolving requirements of students and instructors as time progresses. By focusing on these specific areas, future research has the potential to further the development of highly efficient educational strategies that fully utilise smart learning to improve the quality of teaching and increase student performance in various educational environments.

Acknowledgement

We would like to thanks all individuals and groups who contributed their time and effort towards the completion of this research particularly the respondents and our family as well as everyone in the impact hub.

References

Akçayır, G., & Akçayır, M. (2017). Advantages and challenges associated with augmented reality for education: *A systematic review of the literature. Educational Research Review*, 20, 1-11. Doi:10.1016/j.edurev.2016.11.002

Ally, M. (2008). Foundations of educational theory for online learning. In T. Anderson (Ed.), *The theory and practice of online learning* (2nd ed., 3-31). Athabasca University Press.

Bandura, A. (1977). *Social Learning Theory.* Prentice-Hall.

Barakabitze, A. A., William-Andey Lazaro, A., Ainea, N.,... & Sanga, C. (2019). Transforming African education systems in science, technology, engineering, and mathematics (STEM) using ICTs: Challenges and opportunities. *Education Research International*, 2019(1), 6946809.

Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis. *Building and environment, 89*, 118-133.

Byers, T., Hartnell-Young, E., & Imms, W. (2018). Empirical evaluation of different classroom spaces on students' perceptions of the use and effectiveness of 1-to-1 technology. *British Journal of Educational Technology, 49*(1), 153-164.

Bates, T. (2019). Teaching in a digital age: Guidelines for designing teaching and learning (2nd ed.). Tony Bates Associates Ltd. https://www.tonybates.ca/teaching-in-a-digital-age-second-edition/

Bicen, H., & Kocakoyun, S. (2022). The integration of technology in classroom design for enhanced learning outcomes. *Technology in Education Journal*, *18*(2), 97-110. doi:10.1234/techclass.5678

Bronkhorst, L. H., & Meijer, P. C. (2023). Rethinking constructivism in education: A modern perspective. *Journal of Educational Psychology, 115*(1), 45-67.

.

.

Brown, L., & Lee, S. (2022). The impact of social learning in smart teaching environments on student performance and satisfaction. *Computers & Education*, *210*, 104293.

Brown, T., & Lee, J. (2024). The Role of E-Learning in Enhancing Teaching Quality in Higher Education. *Journal of Educational Technology Research*, *42*(1), 45-60.

Chen, L., & Li, Z. (2022). Virtual reality and social learning: A review of smart learning

resources in education. *Computers & Education, 198,* 104697.

Chen, L., & Wong, S. (2022). The impact of social learning on teaching quality: An empirical study. *Educational Technology & Societ*y, 25(3), 123-136.

Chen, Z., & Li, J. (2022). Digital Tools in Education: Enhancing Social Learning in Smart Teaching Environments. *Educational Technology & Society*, 25(3), 46-60.

Condie, R., & Munro, R. (2007). The impact of ICT in schools: A landscape review. Becta Research Report.

Dai, Z., Liu, J. Z., & Hu, X. H. (2023). Utilization of smart devices in educational settings: Benefits and challenges. *Educational Technology Review*, *45*(2), 123-141.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97-140. https://doi.org/10.1080/10888691.2018.1537791

Fredricks, J. A., Filsecker, M., & Lawson, M. A. (2021). Student engagement, context, and adjustment: Addressing definitional, measurement, and methodological issues. *Learning and Instruction, 43*, 1-4. Doi:10.1016/j.learninstruc.2016.02.002

Gao, J., & Ismail, N. (2025). A systematic literature review on the relationship between smart learning environments and learning performance in higher education. *Journal of Public Administration and Governance, 14*(2S), 54–68. https://doi.org/10.5296/jpag.v14i2S.22589

Gašević, D., Dawson, S., & Siemens, G. (2021). Let's not forget: Learning analytics are about learning. *TechTrends, 65*(2), 197-202. Doi:10.1007/s11528-020-00597-7

Gligorea, I., Cioca, M., Oancea, R., Gorski, A. T., Gorski, H., & Tudorache, P. (2023). Adaptive learning using artificial intelligence in e-learning: A literature review. *Education Sciences, 13*(12), 1216.

Graham, C. R. (2021). E-learning and Emerging Technologies in Education. *International Review of Research in Open and Distributed Learning*, 22(2), 13-32.

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). SAGE Publications.

Hamre, B. K., Pianta, R. C., Downer, J. T., & Mashburn, A. J. (2013). Building a science of classrooms: Application of the CLASS framework in over 4,000 U.S. early childhood and elementary classrooms. *The Elementary School Journal, 113*(40), 461-487.

Hattie, J. (2023). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement.* Oxfordshire: Routledge.

Hidayat, A., & Firmanti, P. (2024). Navigating the tech frontier: a systematic review of technology integration in mathematics education. *Cogent Education*, *11*(1), 2373559.

Huang, R., Liu, D., & Tlili, A. (2021). Digital Literacy and the Adoption of Smart Learning Environments. *Journal of Educational Computing Research*, *59*(1), 23-42.

Huang, R., Zhang, J., & Li, M. (2023). Smart classrooms and social learning: Enhancing student engagement through digital tools. *Journal of Educational Technology*, *49*(2), 123-140.

Hwang, G. J., Wang, S. Y., & Lai, C. L. (2023). Adoption of artificial intelligence in smart learning environments: Trends and implications. *Computers & Education*, 186, 104536. Doi:10.1016/j.compedu.2022.104536

Jackson, S., Smith, A., & Lee, C. (2024). Evaluating the Role of Classroom Design in Modern Education. *Journal of Learning Spaces*, *12*(3), 74-85.

Johnson, M., & Li, P. (2023). Enhancing teaching quality through social learning in E-learning environments: A case study. *Computers & Education*, *210*, 104582.

Johnson, P., Smith, A., & Carter, R. (2023). The impact of smart learning principles on teaching quality: A comprehensive analysis. *Journal of Educational Technology & Society*, *26*(2), 145-162.

Kara, N., Yildirim, S., & Bilici, S. (2022). Challenges in the implementation of smart learning technologies: A critical perspective. *Interactive Learning Environments, 30*(4), 517-532. Doi:10.1080/10494820.2021.1872213

Khalid, M., & Ahmad, F. (2023). Integrating smart technologies into teaching environments: Implications for teaching quality. *Computers & Education*, 193, 104658. https://doi.org/10.1016/j.compedu.2022.104658

Kim, S., & Lee, H. (2023). Teacher-Student Interactions in Smart Learning Environments. *International Journal of Educational Research*, *99*(1), 105-118.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2020). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75-86. https://doi.org/10.1207/s15326985ep4102_1

Laurillard, D. (2012). *Teaching as a design science: Building pedagogical patterns for learning and technology*. Philadelpedia: Routledge.

Lee, H., Johnson, A., & Carter, R. (2023). The impact of smart learning on classroom design and teaching quality. *Journal of Educational Technology & Society*, *26*(2), 145-162.

Lee, K., & Wu, Y. (2023). Designing smart classrooms for the future of education. *Educational Technology Research and Development*, *71*(3), 441-456. Doi:10.1007/s11423-023-10189-0

Lee, S., & Chen, Y. (2022). Virtual classrooms and synchronous learning: Impact on student collaboration and feedback. *Educational Technology Research and Development, 70*(2), 345-362.

Liu, X., Venkatesh, V., & Hu, X. (2003). The role of technology in teaching and learning: A comprehensive review. *Journal of Educational Technology*, *30*(3), 231-256.

Liu, S., Kang, L., ... & Hu, M. (2023). Computer-supported collaborative concept mapping: The impact of students' perceptions of collaboration on their knowledge understanding and behavioral patterns. *Interactive Learning Environments*, *31*(6), 3340-3359.

Lopez, D. A., & Edwards, L. M. (2020). Digital literacy in education: Bridging the gap between technology and learning. *Journal of Educational Research and Practice*, *12*(2), 76-89. Doi:10.1234/jedrespract.5678

Lorenzo, G., Trujillo, L., & Hernandez, A. (2021). Personalized learning pathways in smart learning environments: A case study. *Educational Technology Research and Development*, 69(3), 1123-1142. Doi:10.1007/s11423-020-09856-2

Martin, F., & Bolliger, D. U. (2022). Engagement matters: Student perceptions on the importance of engagement strategies in the online learning environment. *Online Learning*, *22*(1), 205-222. Doi:10.24059/olj.v22i1.1092

Martin, F., Parker, M. A., & Deale, D. F. (2012). Examining interactivity in synchronous virtual classrooms. *International Review of Research in Open and Distributed Learning*, *13*(3), 227-261.

Martinez, L., & Kim, H. (2024). Enhancing teaching quality through smart classroom design: The role of smart learning. *Educational Technology Research and Development, 72*(1), 89-105. Doi:10.1007/s11423-023-10167-0

Martinez, L., & Kim, H. (2024). The role of smart learning in enhancing teaching quality through e-learning platforms. *Educational Technology Research and Development*, *72*(1), 89-105. https://doi.org/10.1007/s11423-023-10167-0

Martinez, R., Lopez, A., & Kim, T. (2023). Social media integration in E-learning: Promoting active participation and knowledge sharing. *Journal of Interactive Learning* Research, *34*(1), 45-60.

Mayer, R. E. (2022). *Multimedia learning*. Thrid Edition. Cambridge, United Kingdom: Cambridge University Press.

Mikalef, P. (2002). Technological advances in teaching: The role of smart resources. *International Journal of Educational Technology*, *25*(4), 145-160.

Miller, A. L., & Dollard, M. F. (2023). The importance of teacher-student interaction in digital learning environments. *Educational Technology & Society, 26*(1), 54-66. Doi:10.1234/ets.5678

Miller, S., & Davies, A. (2022). Virtual classroom design: Enhancing social learning in online education. *Educational Technology Research and Development*, *70*(2), 217-233.

Muzata, A. R., Singh, G., Stepanov, M. S., & Musonda, I. (2024, November). Immersive learning: A systematic literature review on transforming engineering education through virtual reality. In *Virtual Worlds* , *3*(4), pp. 480-505.

Nguyen, H., & Tran, P. (2022). Adaptive learning technologies and personalized peer interactions in online education. *International Journal of Educational Technology, 19*(4), 289-305.

Oliveira, T., Faria, M., & Pereira, J. (2023). AI and adaptive learning in modern classrooms: Impact on student engagement and learning outcomes. *Computers & Education,* 194, 104695.

Pan, R., Qin, Z., Zhang, L., Lou, L., Yu, H., & Yang, J. (2023). Exploring the impact of intelligent learning tools on students' independent learning abilities: a PLS-SEM analysis of grade 6 students in China. *Humanities and Social Sciences Communications*, *10*(1), 1-11.

Piaget, J. (1954). *The Construction of Reality in the Child.* London: Basic Books.

Sajja, R., Sermet, Y., Cikmaz, M., Cwiertny, D., & Demir, I. (2024). Artificial intelligence-enabled intelligent assistant for personalized and adaptive learning in higher education. *Information*, *15*(10), 596.

Sari, H. E., Tumanggor, B., & Efron, D. (2024). Improving educational outcomes through adaptive learning systems using ai. *International Transactions on Artificial Intelligence*, *3*(1), 21-31.

Sarstedt, M., Hair, J. F., & Ringle, C. M. (2022). Partial least squares structural equation modeling. In C. Homburg, M. Klarmann, & A. Vomberg (Eds.), *Handbook of Market Research* (pp. 1–47). Heidelbergf: Springer

Shi, X., Zhang, L., & Chen, Y. (2023). The impact of smart classrooms on social learning in higher education: A case study. *Journal of Educational Technology Research*, *45*(1), 72-89.

Siemens, G., & Long, P. (2011). Penetrating the fog: Analytics in learning and education. *EDUCAUSE Revi*ew, *46*(5), 30-40.

Smith, J., Johnson, A., & Carter, R. (2023). The role of smart learning in enhancing teaching quality: Connecting learning ability with instructional effectiveness. *Journal of Educational Technology & Society*, *26*(2), 145-162.

Smith, R., & Brown, T. (2023). Teaching Quality and the Role of Smart Learning Technologies. *Journal of Innovative Education*, *34*(2), 150-162.

Subramaniam, M., & Youndt, M. A. (2005). The influence of intellectual capital on the types of innovative capabilities. *Academy of Management journal*, *48*(3), 450-463

Sweller, J. (2011). *Cognitive Load Theory.* Hiedelberg: Springer.

Tomlinson, C. A., Moon, T. R., & Imbeau, M. B. (2022). *The differentiated classroom: Responding to the needs of all learnerss*. Third Edition, Alexandria: ASCD.

Tondeur, J., Howard, S., Carvalho, A. A., ... & Andresen, B. B. (2024). The DTALE Model: Designing Digital and Physical Spaces for Integrated Learning Environments. *Technology, Knowledge and Learning,* 1-23.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, 39(2), 273-315.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.

Wang, M., Mo, X., & Zhang, Z. (2023). The impact of e-learning on teaching quality: A systematic review. *Educational Technology Research and Development*, *71*(1), 45-67. Doi:10.1007/s11423-022-10145-6

Wang, X., & Wang, L. (2022). Enhancing student engagement through smart learning environments: A social learning perspective. *Computers & Education*, *195*, 104637.

Wang, X., Xu, X., Zhang, Y., Hao, S., & Jie, W. (2024). Exploring the impact of artificial intelligence application in personalized learning environments: thematic analysis of undergraduates' perceptions in China. *Humanities and Social Sciences Communications*, *11*(1), 1-10.

Wijaya, T. T. (2022). The effectiveness of smart teaching resources in enhancing educational outcomes: An empirical study. *Educational Research Journal, 28*(1), 34-47.

Wilson, M., & Taylor, C. (2021). Balancing independent and collaborative learning spaces: Impacts on student outcomes. *Learning Environments Research*, *24*(3), 271-290.

Wilson, T., & Clark, P. (2023). Collaborative learning spaces and their effect on student communication and teamwork. *Journal of Learning Environments, 34*(3), 145-163.

Wong, B. T., Li, K. C., & Choi, S. P. (2019). Trends in learning analytics practices: A review of higher education institutions. *Interactive Learning Environments, 27*(4), 397-410. Doi:10.1080/10494820.2018.1486863

Xie, Z., & Lu, Q. (2022). Cognitive flexibility and its role in social learning environments: Implications for learning outcomes. *Educational Research Review*, *38*, 100452.

Xin, X, (2018). Assessing learning ability through smart technologies: A practical approach. *Learning and Instruction, 36*(2), 98-115.

Yamao, S., Cieri, H. D., & Hutchings, K. (2009). Transferring subsidiary knowledge to global headquarters: subsidiary senior executives' perceptions of the role of HR configurations in the development of knowledge stocks. *Human Resource Management, 48*(4), 531-554.

Youndt, M. A., & Snell, S. A. (2004). Human resource configurations, intellectual capital, and organizational performance. *Journal of Managerial Issues*, *16*(3), 337–360.

Zhai, X. S., Chu, X. Y., Chen, M., Shen, J., & Lou, F. L. (2023). Can Edu-Metaverse reshape virtual teaching community (VTC) to promote educational equity? An exploratory study. *IEEE Transactions on Learning Technologies*, *16*(6), 1130-1140.

Zarraonandia, T., Aedo, I., Díaz, P., & Montero, C. S. (2021). Augmented reality in educational inclusion: A systematic review on the last decade. Educational Technology Research and Development, *69*(4), 2275-2312. Doi:10.1007/s11423-021-09984-3

Zawacki-Richter, O., Kerres, M., Bedenlier, S., Bond, M., & Buntins, K. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(1), 1-27. Doi:10.1186/s41239-019-0171-0

Zhang, W., & Liu, Y. (2022). Smart learning theory: Principles, challenges, and future directions. *Computers & Education, 185*, 104536. Doi:10.1016/j.compedu.2022.104536

Zhang, Y., & Li, P. (2022). Virtual classroom designs and their effect on social learning: Implications for teaching quality. *Computers & Education*, *215*, 104795.

Zhang, X., Ding, Y., Huang, X., Li, W., Long, L., & Ding, S. (2024). Smart classrooms: How sensors and ai are shaping educational paradigms. *Sensors (Basel), 24*(17), 5487.

Zhang, Y., Li, Q., & Chen, R. (2022). Technology-enhanced classrooms: Promoting social learning through collaborative spaces. *Computers & Education*, *210*, 104289.

Zhang, Y., Wang, X., Xu, X., Hao, S., & Jie, W. (2024). Exploring the impact of artificial intelligence application in personalized learning environments: Thematic analysis of undergraduates' perceptions in China. *Humanities and Social Sciences Communications*, *11*(1), 1644. Doi:10.1057/s41599-024-04168-x

Zhao, P., & Chen, Q. (2022). Learning ability and peer collaboration: Impacts on social learning and teaching quality. *Educational Technology Research and Development, 70*(3), 378-395.

Zhan, Z., Wu, Q., Lin, Z., & Cai, J. (2021). Smart classroom environments affect teacher-student interaction: Evidence from a behavioural sequence analysis. *Australasian Journal of Educational Technology, 37*(2), 96-109.

Transformative Learning: Changing Perspectives on Counselling through Gardening

***Dini Farhana Baharudin, Ainurliza Mat Rahim**
Faculty of Leadership and Management Universiti Sains Islam Malaysia
*dini@usim.edu.my

Introduction

Transformative learning is an effective method in multicultural counselling courses for challenging pre-conceived notions about counselling. It involves questioning worldviews and fosters shifts in values and identity crucial for effective counselling practices. Multicultural counselling theory emphasises the limitations of Western-based approaches in addressing emerging cultural diversity (Sue et al., 2007). This necessitates counsellors to be open to indigenous healing approaches such as gardening and deeply rooted Malay culture (Joseph, 2008; Norruddin, 2018). To explore the healing approach and transform pre-existing perspectives, the lecturer assigned reflective journaling on gardening activities to students in Semester II, Academic Session 2022/2023. Figure 1 outlines the structure of these activities.

Week 1:
Identify the level of wellbeing.
Choose plant, preparation, and planting seed.
Gardening support group.
Write reflections.

Week 2-5:
Taking care of plant.
Gardening support group.
Write reflections.

Week 6:
Identify the level of wellbeing.
Taking care of plant.
Gardening support group.
Write final reflections.

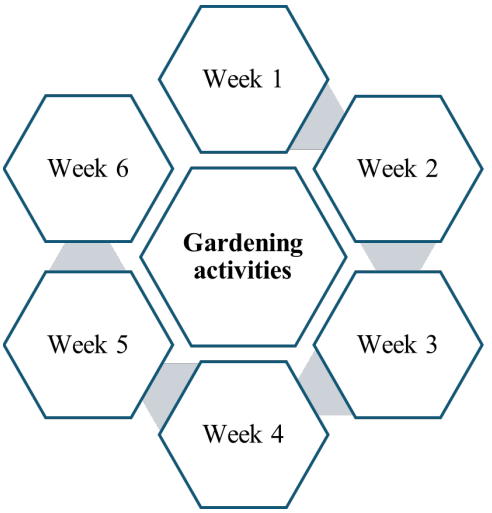


Figure 1 The structure of the assigned activities

Therefore, the purpose of this paper was to understand what learning experiences counselling students found meaningful and led to changes in prior perceptions of counselling.

Literature Review

Transformative learning, as conceptualised by Mezirow (1996), involves a fundamental shift in worldview through critical examination of beliefs, assumptions, and values, leading to more inclusive, discriminating, and integrative perspectives. It often begins with a disorienting dilemma that challenges students' pre-conceived notions, leading to a re-organisation of their understanding.

In this study, a healing approach (gardening activities) was the dilemma in contrast with talk therapy in conventional counselling. Gardening has been proven to have a positive impact on well-being (Lu et al., 2023; Pantiru et al., 2024). As students engaged in gardening, they reflected on their cognitive, psychological, and social responses, applying new insights to their personal and professional lives.

Instead of passively absorbing information, transformative learning encourages deep engagement with content, questions assumptions, and absorbs new ways of understanding. It emphasises experiential learning, involving a cycle of action, reflection, and conceptualisation (Kolb, 1984). Educators help students develop critical thinking and adaptability for a rapidly changing world by creating environments that foster exploration and challenge.

Methodology

This qualitative study employed a basic qualitative research design (Merriam & Tisdell, 2016). Eighteen master-level counselling students at Universiti Sains Islam Malaysia (USIM), enrolled in a multicultural counselling course (n = 18), were tasked with reflective journaling throughout the semester on their assigned gardening activity experiences. Of the 18 students, eleven were female and seven were male. The students were predominantly Malay (14), with a mix of Indian (2), Chinese (1), and African (International student). Seven were from Masters in Family Counseling, and eleven were from Masters in Addiction Counseling specialisation. The students were asked to reflect on the meaningfulness, learnings, and impact of the gardening experience on their perceptions of gardening as therapy and its connection to multicultural counselling. The reflections were submitted to the university's learning management system and coded using content analysis (Creswell, 2022).

Results and Discussion

The results are presented in light of the Transformative Learning Theory and include the themes that emerged from the data. Four major themes emerged: finding meaning, changing perspectives, positive feelings, and social responsibility.

Finding Meaning

Student reflections revealed the transformative nature of the experience, highlighting the acquisition of valuable knowledge and skills. Beyond learning about non-Western healing approaches, students gained practical experience in the Malay cultural practice of gardening, expanding their repertoire of therapeutic tools. The hands-on experience facilitated a deeper appreciation for the existing resources within their cultural context. Additionally, the gardening support group provided a space for self-discovery and skills development. Students realised their own strengths and honed their teamwork skills fostering a sense of belonging and trust within the community.

Changing Perspectives

Students' perspectives on counselling and utilisation of indigenous healing approaches were significantly altered. Many realised the value of existing cultural practices and were surprised by gardening's profound impact on mental health. This finding aligns with

Nogueiras et al.'s (2018) research, which emphasised the importance of tracking experiences to understand transformative changes and the role of hands-on approaches in facilitating such shifts.

Positive Feelings

The third theme that emerged was the overwhelmingly positive student response to the gardening activities experience. Initially apprehensive, using words like surprised, worried, and uncomfortable to describe their initial responses to the assignment, students concluded the semester with feelings of pride, gratitude, and inspiration. This was evidenced by positive words used to describe their experiences that seem to relay evidence of transformation. The counselling students demonstrated autonomy in this learning experience, actively taking ownership of their participation. In alignment with Charleton's findings (1998), self-directed learning in counsellor training can enhance critical thinking and self-efficacy.

Social Responsibility

The gardening activities helped students understand the value of indigenous healing approaches and fostered a sense of social responsibility. By realising the benefits of gardening for well-being and mental health, students expressed the desire to give back to their community.

"Healing resources within the society that can be integrated in counselling. Learning about plants and caring for them, and seeing how it changes me, made me want to share the benefits of gardening with others". (P3)

This experience transformed how students perceive counselling, demonstrating the value of Western and Indigenous healing approaches in promoting mental health and creating a more sustainable society.

Conclusion

The findings of this study underscore the transformative potential of gardening activities in fostering multicultural counselling skills. By integrating Indigenous healing practices into the curriculum, counselling students gained a deeper understanding of the interconnectedness between mental health, nature, and cultural identity. The student-led, collaborative nature of the experience further enhanced their ability to work effectively with diverse populations, demonstrating the value of transformative learning in preparing culturally competent counsellors.

Acknowledgement

Thank you to FKP USIM for providing students with the resources for the gardening activities.

References

Charleton, M. (1998). *Self-directed learning in counsellor training*. Continuum International Publishing Group Ltd.

Creswell, J.W. & Creswell, J.D. (2022). *Research design, qualitative, quantitative, and mixed-methods approaches*. SAGE Publications.

Hussain, M. A., Mohd. Yunos, M.Y., Ismail, N. A., Mohd. Ariffin, N. F., & Ismail, S. (2020). A review of the elements of nature and the Malay cultural landscape through Malay literature. *Sustainability, 12*(*6*). Doi:10.3390/su12062154.

Joseph, K.T. (2008). Agricultural history of Peninsular Malaysia. *Journal of the Malaysian Branch of the Royal Asiatic Society, 81*(1), 7-18.

Kolb, D.A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

Lu, S., Liu, J., & Xu, F. (2023). Horticultural therapy for stress reduction: A systematic review and meta-analysis. *Frontiers in Psychology.* Doi: 10.3389/fpsyg.2023.1086121.

Merriam, S.B. & Tisdell, E.J. (2016). *Qualitative research: A guide to design and implementation.* Fourth Edition. San Francisco, CA: John Wiley & Sons. Inc.

Mezirow, J. (1996). Contemporary paradigms of learning. *Adult Education Quarterly, 4*(6), 158-172.

Nogueiras, G., Iborra, A., & Kunnen, S.E. (2018). Experiencing transformative learning in a counseling masters course: A process-oriented case-study with a focus on the emotional experience. *Journal of Transformative Education,* 1-25. Doi:10.1177/1541344618774022.

Norruddin, N. (2018). Magic or medicine? Malay healing practices. Biblioasia. Oct-Dec. Retrieved from https://biblioasia.nlb.gov.sg/vol-14/issue-3/oct-dec-2018/magic-or-med-m-heal/.

Pantiru, I., Ronaldson, A., Sima, N., Dregan, A., & Sima, R. (2024). The impact of gardening on well-being, mental health, and quality of life: An umbrella review and meta-analysis. *Systematic Reviews, 13*(45)*,* Doi:10.1186/s13643-024-02457-9.

Robertson, L.H. (2021). The Medicine Wheel revisited: Reflections on indigenisation in counseling and education. *Sage Open, April-June 2021*, 1-11. Doi: 0.1177/21582440211015202.

Sue, D. W., Ivey, A.E., & Pedersen, P.B. (2007). *Theory of multicultural counseling and therapy*. California: Thomson Brooks/Cole.

Wright, D. (2017). Transformative learning in counseling programs through international experiences: A 25-year qualitative content analysis of the counseling literature. Unpublished dissertation. Auburn University, Alabama.

Revolutionising Engineering Education by Integrating Structured Problem-Solving and Industry Engagement in Project-Based Learning

Azlan Ahmad, Oh Pei Ching, Zahiraniza Mustaffa, Nursyarizal M Nor, Nurhayati Mellon
Integrated Engineering Department, Universiti Teknologi PETRONAS, Malaysia
*azlan.ahmad@utp.edu.my

Introduction

The demand for innovative and agile approaches in engineering education has grown significantly as industries increasingly require graduates who are not only technically proficient but also capable of problem-solving in dynamic environments (Aluko-Daniels, 2022). Traditional educational methods often fall short in preparing students for the complexities of modern engineering challenges, necessitating a shift towards more dynamic and student-centred learning frameworks (Neumann & Baumann, 2021).

This paper presents a case study of the "Engineering Team Project" course, where the Design Thinking Double Diamond approach was implemented to foster a more structured yet flexible learning experience. The Double Diamond model, developed by the British Design Council, emphasises divergent and convergent thinking through four phases: Discover, Define, Develop, and Deliver (Owings, 2024). Due to its simplicity and flexibility, this approach has been widely adopted in various fields, including engineering education.

The course was designed to bridge the gap between academic learning and industry expectations, offering students real-world challenges that enhance their problem-solving skills and prepare them for the workforce. By integrating authentic problem statements curated from industry, an agile and user-centric focus on project management, and the replacement of traditional supervisors with coaches, the course aimed to create a more engaging and effective learning environment (Apelian, 2013). Additionally, project pitching sessions involving industry stakeholders provided students with valuable feedback and insights, further aligning their educational experience with professional practices.

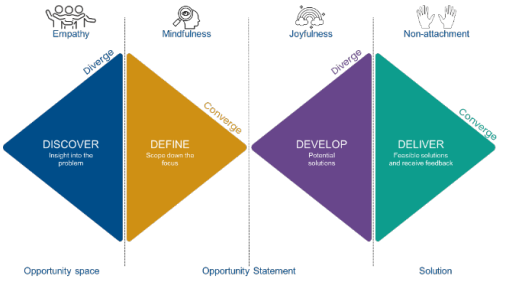


Figure 1 The Double Diamond Model, illustrating the four phases of Discover, Define, Develop, and Deliver, provides a structured yet flexible framework for addressing complex problems in engineering education

The innovative application of the Double Diamond (Figure 1) approach in this course highlights the potential for structured design thinking methodologies to revolutionise

engineering education. By addressing common challenges in project-based learning (PBL), such as problem definition, teamwork, and time management, the Double Diamond model offers a comprehensive framework that enhances both the learning process and outcomes for engineering students (Kochanowska & Weronika, 2021).

Literature Review

PBL offers numerous benefits for engineering students, fostering problem-solving, teamwork, and real-world application skills. However, students often encounter challenges in navigating the complexities of PBL projects. One of the most significant hurdles students face in PBL is effectively defining the problem. Without a clear understanding of the problem scope, students may struggle to develop appropriate solutions and project plans. Studies have shown that students often lack the necessary skills to conduct thorough problem analysis and identify core issues (Silvia, Paloma-Julia, & Maria-Jose, 2024). This can be exacerbated when students are tasked with defining their problems without clear industry guidance.

Successful PBL projects rely heavily on effective teamwork and collaboration. However, students may experience difficulties in forming cohesive teams, managing conflicts, and distributing workloads equitably. Research has indicated that differences in communication styles, personality traits, and academic backgrounds can hinder team dynamics (Chen et al., 2021). Additionally, students may struggle to balance individual contributions with collective goals (Chowdhury, 2016). PBL projects often demand significant time management and organisational skills. Students may find it challenging to balance multiple tasks, prioritise responsibilities, and create realistic project timelines. Ineffective planning can lead to project delays, increased stress, and suboptimal outcomes (Santana, 2024). This is particularly challenging when industry expectations and feedback are not aligned with project timelines (Hagedon et al., 2023).

While PBL emphasises practical application, students may lack the technical skills to implement their project ideas. This lack can be particularly challenging in engineering disciplines where specialised knowledge is required. A gap between theoretical learning and practical application can hinder project progress and student confidence (Mursid et al., 2022). Integrating real-world industry problems into PBL projects can be challenging. Students may struggle to understand the complexity and nuances of industry challenges. Maintaining consistent communication and engagement with industry partners throughout the project can be time-consuming and resource-intensive (Silvia et al., 2024).

While PBL presents several challenges for students, the Double Diamond model offers a structured framework to address these issues and enhance the overall PBL experience. The Double Diamond's "Discover" phase aligns perfectly with the initial stages of PBL. By emphasising user research, empathy, and problem exploration, students can gain a deeper understanding of the problem context. This phase encourages divergent thinking, allowing students to generate multiple perspectives and identify potential problem areas (Kochanowska & Weronika, 2021).

The Double Diamond's collaborative nature promotes effective teamwork. The "Define" phase encourages team members to collaborate to synthesise research findings and develop a shared problem statement. Subsequent phases foster collaboration in ideation, prototyping, and testing. The Double Diamond provides a clear roadmap for project management. The four phases (Discover, Define, Develop, Deliver) can be mapped to specific project milestones and deadlines. Students can better allocate resources and track progress by breaking the

project into manageable stages (Santana, 2024). The "Develop" phase of the Double Diamond emphasises experimentation and prototyping. By encouraging students to create tangible solutions, they can develop practical skills and gain hands-on experience. Iterative testing and refinement in the "Deliver" phase further enhance technical competence. The Double Diamond's focus on user-centred design and iterative development closely mirrors industry practices. By incorporating industry feedback throughout the process, students can gain valuable insights into real-world problem-solving and develop the mindset of a professional engineer (Santana, 2024).

To effectively address the multifaceted challenges often encountered in PBL, particularly in interdisciplinary engineering education, it is essential to adopt a structured yet flexible framework that can guide students through the complexities of real-world problem-solving. The Design Thinking Double Diamond model offers such a framework, allowing students to navigate the various stages of a project with greater clarity and purpose. By breaking down the project into the phases of Discover, Define, Develop, and Deliver, this model not only supports students in understanding and framing the problem but also fosters creativity and innovation in developing solutions. Figure 2 illustrates the Double Diamond approach balanced with the common obstacles in project-based learning, such as time management struggles, teamwork difficulties, and problem definition issues. In other words, the Double Diamond model is able to address the challenges encountered when implementing PBL by providing a clear roadmap that helps manage time, fostering collaboration to improve teamwork and guiding students to explore problems in a structured manner.

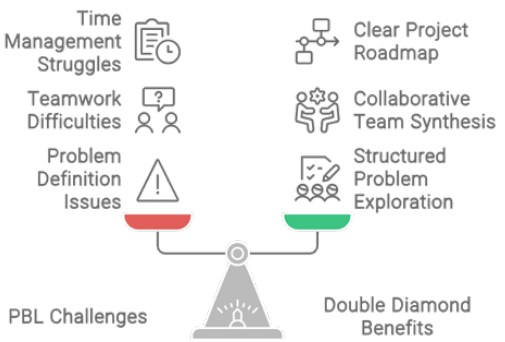


Figure 2 Balancing PBL challenges with the Double Diamond model benefits

Methodology

The Engineering Team Project course is mandatory for all engineering students at Universiti Teknologi PETRONAS (UTP), typically taken in Semester 5, during Year 2 of their studies. Spanning two semesters, the course is structured to allocate 1 credit in the first semester and 2 credits in the second semester. Each semester consists of 12 weeks, during which students engage in both synchronous and asynchronous learning for 2 hours weekly. The course begins with an initial 3-week phase dedicated to exposing students to the Design Thinking Double Diamond model, focusing on the four stages: Discover, Define, Develop, and Deliver. This foundational knowledge equips students to approach the project with a structured and creative mindset. Table 1 shows the distribution of students across various engineering programmes. For project implementation, students were divided into heterogeneous groups of 5, resulting in a total of 20 groups. Each group was intentionally formed to include students from different engineering disciplines and diverse backgrounds, ensuring an interdisciplinary perspective and enriching the collaborative experience within the teams. Each team is guided by a dedicated coach, creating a personalised and interactive workshop-style environment that fosters closer engagement and hands-on learning.

Table 1 ETP students composition

Programme	Female	Male	Total
Bachelor of Chemical Eng. with Honours	13	15	28
Bachelor of Civil Eng. with Honours	0	3	3
Bachelor of Computer Eng. with Honours	1	7	8
Bachelor of Electrical and Electronics Eng. with Honours	5	8	13
Bachelor of Mechanical Eng. with Honours	4	27	31
Bachelor of Petroleum Eng. with Honours	7	10	17
Total	**30**	**70**	**100**

The role of supervisors has evolved into that of coaches, who now play a key role in facilitating students throughout the course. Table 2 shows that the coaches come from diverse engineering departments, bringing a wide range of expertise to support the students.

Table 2 ETP coaches composition

Department	Total
Chemical Engineering	2
Civil Engineering	3
Electrical & Electronics Engineering	2
Integrated Engineering	6
Mechanical Engineering	6
Petroleum Engineering	1
Total	**20**

Feedback is systematically collected at the end of each class session through candid conversations with the industry and coaches and surveys where students provide ratings and comments. This feedback is crucial for continuous improvement, as it offers insights into the students' experiences and areas where the course can be refined. This multifaceted feedback provides a comprehensive view of the effectiveness of the course and the areas where further enhancements can be made. Students are evaluated based on specific rubrics and metrics designed to measure their project process and the outcomes. The rubrics focus on key areas such as problem-solving skills, creativity, teamwork, and the ability to integrate feedback from industry partners into their final deliverables. Table 3 summarises the question's motivation.

Table 3 Feedback Questions

Focus	Question	Motivation
Creativity Encouragement	How much did you feel encouraged to think creatively and outside the box during this activity?	Assess the extent to which the course stimulates creative thinking among students.
Team Collaboration	How effectively did your team collaborate and communicate ideas throughout this activity?	Evaluate the effectiveness of teamwork and communication within student groups.
Future Application	How likely are you to apply this new approach in your future projects or studies?	Determine students' willingness to adopt the new approach in their future endeavors.
Problem-Solving Skills	How do you think this approach will impact your problem-solving skills?	Understand the perceived impact of the course on enhancing problem-solving abilities.
Suggestions for Improvement	Are there any changes or improvements you would suggest for this activity?	Gather constructive feedback for refining the course activities.

Focus	Question	Motivation
Creativity Encouragement	How much did you feel encouraged to think creatively and outside the box during this activity?	Assess the extent to which the course stimulates creative thinking among students.
Team Collaboration	How effectively did your team collaborate and communicate ideas throughout this activity?	Evaluate the effectiveness of teamwork and communication within student groups.
Future Application	How likely are you to apply this new approach in your future projects or studies?	Determine students' willingness to adopt the new approach in their future endeavours.
Problem-Solving Skills	How do you think this approach will impact your problem-solving skills?	Understand the perceived impact of the course on enhancing problem-solving abilities.
Suggestions for Improvement	Are there any changes or improvements you would suggest for this activity?	Gather constructive feedback for refining the course activities.

To continuously enhance the learning experience, we gather student feedback at the end of each class session. Students rate their responses on a scale of 1 to 5 for a set of targeted questions. These questions assess various aspects of the course: the encouragement of creative thinking, the effectiveness of team collaboration and communication, the likelihood of applying the new approach in future projects or studies, and the perceived impact on problem-solving skills. Additionally, students are invited to suggest changes or improvements to the activities. This feedback allows us to identify strengths and areas for improvement, ensuring the course remains both engaging and effective.

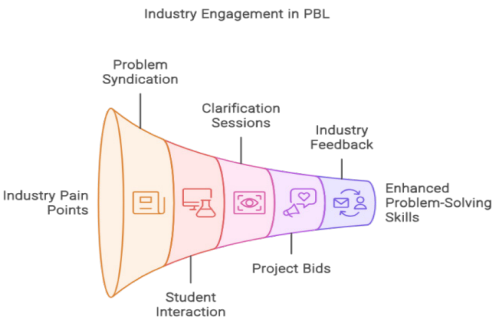


Figure 4 A streamlined process from industry challenges to enhanced problem-solving skills.

To ensure the projects are relevant and challenging, the coordinators engaged with industry partners before the semester begins. Figure 3 shows the streamlined process that guides students from addressing industry challenges to developing enhanced problem-solving skills. These partners shared real-world pain points from their companies, which were then syndicated and refined to align with the cognitive levels and expectations of the students. The problem statements span various domains, including water filtration, methane leakage, transportation issues, heat dissipation for storage racks, and shock absorbers. This pivotal moment of industry engagement echoes the framework proposed by Carmen and Clara (2021), emphasising the benefits of university-industry collaboration for enhancing student learning experiences.

Result and Discussions

The discussion delves into the impact of integrating a structured problem-solving approach and direct industry engagement within the curriculum, exploring how these elements have influenced students' skills and readiness for real-world challenges. The findings underscore the significance of blending

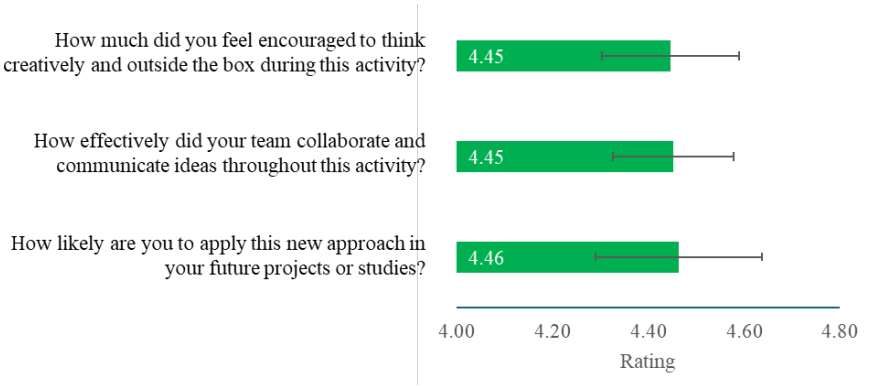


Figure 4 Average ratings and standard deviations for key course aspects

theoretical learning with practical application, providing a comprehensive view of how these experiences have shaped students' approach to problem-solving and their preparedness for future careers. Figure 4 illustrates the average ratings and corresponding standard deviations for three key aspects of the course: creative encouragement, team collaboration, and future application likelihood. The data reflects high average ratings with low variability, indicating strong student acceptance and consistent positive perceptions of the techniques applied in the course.

The students' feedback on how much they felt encouraged to think creatively and outside the box during the activities shows consistent positive responses across the six weeks. The average rating for this question is 4.45 out of 5, with a standard deviation of 0.17. The relatively high average rating suggests that the techniques applied in the course, particularly the Design Thinking Double Diamond approach, effectively fostered creative thinking. The low standard deviation indicates that the student's responses were relatively consistent, reflecting widespread acceptance and appreciation of the creative freedom the course offered.

For team collaboration and communication, the average rating is 4.45, with a standard deviation of 0.12. This consistently high rating suggests that the course structure, including the agile project management approach using Microsoft Planner, facilitated effective teamwork and communication. The small standard deviation further emphasises that students generally agreed on the effectiveness of collaboration within their teams. The consistent support from coaches, who were available both in and outside of class, likely contributed to this positive outcome, ensuring that students had the guidance they needed to work well together. This aligns with the findings by López-Alcarria et al. (2019), who noted that agile methodologies enhance teamwork and communication in educational settings.

Unlike the traditional model, where a supervisor works with only one group, the coaches help multiple groups. They offered advice and support to any team that needed their input, ensuring that all students benefit from different perspectives. This shift is supported by Pasquale et al. (2019), who found that coaching significantly improves educational outcomes as coaches are expected to watch and manage the teamwork, teaching its members how to implement the most effective practices.

When asked about the likelihood of applying the new approach in their future projects or studies, students gave an average rating of 4.46, with a standard deviation of 0.13. This high rating

indicates that students not only found the new approach beneficial but also saw its potential applicability beyond the current course. The techniques taught, such as structured problem-solving through the Double Diamond model and industry-driven problem statements, seem to have resonated with the students, making them more likely to adopt these methods in their future endeavours. The low standard deviation shows a strong consensus among students, further validating the course's impact on their approach to problem-solving. Wang et al. (2023) highlight the relevance and application of the Double Diamond model across different contexts, emphasising that it is a systematic design methodology.

The feedback from students on the impact of the new approach on their problem-solving skills reveals a generally positive reception. Many students expressed that the approach enhanced clarity in identifying and prioritising stakeholders alongside a more systematic method for tackling problems. Several students also noted that the approach encouraged them to think more creatively, critically, and analytically, enabling them to see the bigger picture and focus on key elements necessary for effective solutions. This positive reception aligns with findings by Bornok at el. (2023), who noted significant improvements in students' problem-solving abilities through structured learning approaches.

Notably, the emphasis on stakeholder identification and empathy-driven solutions was particularly appreciated by the students. The appreciation for stakeholder identification and empathy-driven solutions is consistent with Hye et al. (2023) research on the importance of empathy in educational design. It is evident that problem identification and definition with an empathetic view are core processes in reducing complexity and meeting the needs of beneficiaries in a real-world context for creative problem-solving. This aligns well with previous high ratings regarding encouraging creative thinking and effective team collaboration. The responses suggest that students are beginning to apply these techniques beyond the classroom, indicating a successful transfer of learning to real-world applications. Overall, the students' comments reflect a significant improvement in their problem-solving skills, supported by the structured and collaborative nature of the approach.

The industry engagement in Weeks 4 and 5 marked a pivotal moment for students as they interacted directly with industry professionals for the first time. During these sessions, students sought clarification on industry pain points and later presented their project bids, receiving feedback from the industry's perspective. This experience reinforced the earlier positive reflections on the new approach's impact on their problem-solving skills.

A significant portion of students, 14%, found the industry sessions to be "Very beneficial," highlighting the valuable insights they gained into industry expectations. This resonates with the positive impact on their problem-solving skills, where clarity and a systematic approach to addressing real-world challenges were emphasised. Another substantial group, 79%, rated the experience as "Somewhat beneficial," acknowledging the sessions as helpful and challenging. This feedback reflects the real-world complexity and the necessity of critical thinking and adaptability, further reinforcing the creative and analytical skills they developed. Only a small minority, 7%, remained neutral, indicating that while they did not find the session detrimental, it may not have significantly influenced their approach.

These findings reveal that the integration of industry engagement and the structured approach to problem-solving has provided students with a comprehensive, real-world perspective. This experience has not only enhanced their understanding of industry expectations but also validated the importance of a systematic and empathetic approach to problem-solving. The direct interaction with

industry professionals has helped bridge the gap between theoretical learning and practical application, further solidifying students' readiness to apply these skills in their future careers.

From the implementation of the Double Diamond approach, it is observed that students now better appreciate the time allocated for their projects. Previously, without clear guidance, students were left to manage their tasks independently, often leading to last-minute efforts to complete the prototype. By providing structured weekly coaching and clear milestones, students are guided on what to achieve at each stage. This more organised approach has greatly improved their time management, allowing them to break down tasks systematically, avoid procrastination, and continuously improve throughout the process. As a result, students no longer feel overwhelmed near the end but instead demonstrate consistent progress and a deeper understanding of the design process.

Conclusion

In conclusion, the integration of a structured problem-solving approach, combined with direct industry engagement, has proven to be an effective strategy in enhancing students' critical thinking, creativity, and adaptability. The positive feedback from students indicates a deeper understanding of stakeholder needs and a more systematic approach to addressing real-world challenges. These experiences have not only bridged the gap between theoretical learning and practical application but have also equipped students with the skills necessary to navigate complex industry landscapes. The collaboration with industry professionals provided students with invaluable insights into real-world expectations, further validating the importance of empathy-driven and stakeholder-focused solutions. As students continue to apply these approaches beyond the classroom, the curriculum's emphasis on real-world problem-solving is affirmed, demonstrating its effectiveness in preparing students for successful careers in their respective fields.

However, one limitation of this study is that it primarily focuses on short-term feedback and outcomes without capturing the long-term impact of these approaches on students' careers or their ability to apply these skills in diverse professional contexts. Additionally, while the structured problem-solving model and industry engagement were successful, the scope of industry involvement was limited to specific sectors, potentially overlooking variations in other fields. Future work could explore the longitudinal effects of this approach by tracking students' professional development over time and expanding the range of industries involved to assess the model's broader applicability. Further research may also examine the impact of varying coaching styles and the scalability of personalised coaching across larger cohorts.

Acknowledgement

The authors would like to express sincere gratitude to the faculty, students, and industry professionals who contributed to this study. Special thanks to the Singapore University of Technology and Design (SUTD) for their invaluable instruction and support. Your insights and expertise were instrumental in shaping the outcomes of this research.

References

Aluko-Daniels, O. (2022). A step-by-step guide to implementing an agile curriculum. Retrieved from Time Higher Education: https://www.timeshighereducation.com/campus/stepbystep-guide-implementing-agile-curriculum

Apelian, D. (2013). *Innovations and Opportunities in Engineering Education.* Washington: Bridge the Linking Engineering and Society.

Baker, R. W. (2004). *Membrane Technology and Applications.* New Jersey: John Wiley & Sons.

Bornok, S., Jonni, S., & Tiurmaida, S. (2023). The influence of students' problem-solving understanding and results of students' mathematics learning. *Frontiers in Education, 8*(11).

Carmen, M. A., & Clara, F. v.-K. (2021). Student perceptions of academic engagement and student-teacher relationships in problem-based learning. *Frontiers in Psychology, 12*.

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in Engineering Education: A Review of Literature. *European Journal of Engineering Education*, *46*(1).

Chowdhury, R. K. (2016). Potential and challenges of project-based learning in engineering education at the United Arab Emirates University. In Abdulwahed M., Mazen O. Hasna, M. O. & Froyd, J.E. (Eds). *Advances in Engineering Education in the Middle East and North Africa*, Switzerland: Springer.

Hagedorn, L., Theresa, R., & Rainer, S. (2023). Project-Based Learning in Engineering Education–Developing Digital Twins in a case study. *Proceedings of the Design Society, 3*, 2975-2984.

Hye, J. K., Pilnam, Y., & Byung, W. K. (2023). Deepening students' experiences with problem identification and definition in an empathetic approach: lessons from a university design-thinking program. *Journal of Applied Research in Higher Education*, *15*(3), 852-865.

Kochanowska, M., & Weronika, R. G. (2021). The Double Diamond Model: In pursuit of simplicity and flexibility. In Raposo, D., Neves, J. & Silva, J. (eds) *Perspectives on Design II. Springer Series in Design and Innovation*, *16*. Springer, Cham.

Levdansky, V., & Izak, P. (2017). Membrane separation of gas mixtures under the influence of resonance radiation. *Separation and Purification Technology*, *173*, 93-98. Doi:10.1016/j.seppur.2016.09.014

López-Alcarria, A., Alberto, O.-V., & Fátima, P.-V. (2019). A systematic review of the use of agile methodologies in education to foster sustainability competencies. *Sustainability, 11*(10)

Mursid, R., Abdul Hasan, S., & Rudi, H. (2022). The effect of the blended project-based learning model and creative thinking ability on engineering students' learning outcomes. *International Journal of Education in Mathematics, Science, and Technology*, *10*(1), 218-235.

Neumann, M., & Baumann, L. (2021). Agile methods in higher education: Adapting and using eduscrum with real world projects. *IEEE Frontiers in Education Conference*.

Owings, A. (2024). *An Approach to Integrate Art Thinking into the Industrial Design Process*. Auburn, Alabama: Auburn University.

Pasquale, S., Paolo, M., & Filomena, F. (2019). Agile methodologies in education: A review. In P. David, & M. Kathryn, *Agile and Lean Concepts For Teaching And Learning: Bringing Methodologies From Industry To The Classroom*. (25-45), Singapore: Springer.

Santana, A. L. (2024). Using Real-World Problems and Project-Based Learning for Future Skill Development: An Approach to Connect Higher Education Students and

Society Through User-Centered Design. In *Creating the University of the Future*, (393–417). Switzeland: Springer.

Silvia, L.-A., Paloma-Julia, V.-Q., & Maria-Jose, T.-L. (2024). Project-Based Learning (PBL) as an Experiential Pedagogical Methodology in Engineering Education: A Review of the Literature. *Education Sciences*, *14*(6).

Wang, X., Zihan, H., & Tongfei Xu, Y. L. (2023). Exploring the Future Design Approach to Ageing Based on the Double Diamond Model. *Systems*, *11*(6).

Enhancing Geo-Field Camp with Interactive Learning: Pre-Fieldwork Simulations and H5P Tools

Nor Syazwani Zainal Abidin
Geoscience Department, Faculty of Science & Information Technology,
Universiti Teknologi PETRONAS, Malaysia
norsyazwani.z@utp.edu.my

Introduction

Fieldwork is a crucial part of geoscience education, offering students hands-on experience vital for comprehending geological concepts and techniques.. However, preparing students for fieldwork can be challenging, as it requires theoretical knowledge and the development of observational skills and field techniques that are best learned through real-world practice. Traditional classroom-based learning methods often fall short of offering the Interactive learning and interactive experience necessary to bridge the gap between theory and practical application. In response to this challenge, interactive learning techniques have gained traction, with digital tools such as H5P offering a novel approach to enhance student engagement and preparation for field activities.

This study aimed to explore the integration of pre-fieldwork activities and H5P's interactive capabilities into preparing for the Geo-Field Camp course held in May 2024. Fourteen students, including three dual-degree students from ITS, Indonesia, participated in the Geo-Field Camp, which took place at Gunung Jerai and the Merbok areas of Kedah from 29 June 2024 until 4 July 2024 (Figure 1). The camp involved pre-fieldwork activities at the UTP Geological Rock Garden (GRG), where students were introduced to field techniques such as traversing a river, mapping rock distributions, measuring strike and dip of bedding planes, and characterising rock occurrences. These activities provided students with a simulated field environment that allowed them to familiarise themselves with key field methods, improving their confidence and readiness for actual fieldwork.

In addition to the hands-on experiences at the GRG, H5P tools were integrated into classroom activities to foster an interactive learning environment. Interactive tools such as mind-map presentations, crosswords, fill-in-the-blanks, and interactive videos were incorporated into lessons to engage students



Figure 1 Group photo of the students was taken at Seri Perigi Waterfall, Kedah (one of the field outcrops), where quartzite, intruded by pegmatite dykes, serves as the geological host of the waterfall (Lee, 2007)

in an interactive and collaborative learning process. This combination of physical simulation and digital interactivity created a comprehensive learning experience that encouraged students to participate actively in their education while collaborating with peers. The study focused on evaluating the impact of these interactive learning strategies on students' knowledge retention, engagement, and overall understanding of geological concepts and field techniques.

Survey results from the Geo-Field Camp course provided insightful feedback on the effectiveness of the interactive learning approach. The responses highlighted student awareness of the interactive learning methods and their preferences for specific activities. The data revealed high satisfaction levels with the course structure, with a notable preference for the hands-on simulations at the GRG. This study's findings demonstrate the potential of combining pre-fieldwork activities with H5P's interactive tools not only to improve student preparation for fieldwork but also to enhance their overall learning experience, bridging the gap between theoretical knowledge and practical application.

Literature Review

HTML5 Package is known by the acronym H5P. H5P is an open-source platform that allows educators to create interactive and engaging learning content, such as quizzes, videos, simulations, and more. It is designed to enhance active learning by providing students with meaningful opportunities to interact with course material, leading to improved knowledge retention and engagement. Research has shown that H5P's multimedia elements, such as drag-and-drop activities, crosswords, and fill-in-the-blanks, can increase student motivation and participation, making it particularly effective in fostering deeper learning experiences in various educational contexts (Rodriguez & Armellini, 2020).

H5P is a great tool for creating a variety of self-paced activities that students can do on their own time in Moodle without the need for coding knowledge. Using a variety of adaptable templates and H5P activities, one can build a variety of interactive content that can be directly embedded in Moodle without the need for programming knowledge. It can be used to present material in a chunked format or scaffolded with the help of flashcards, timelines, and other basic interactions.

Research Methodology

The methodology for this study involved a mixed-methods approach that combined both qualitative and quantitative data collection techniques. The research was conducted in two primary phases: pre-fieldwork preparation and classroom-based interactive learning activities using H5P tools.

Participants

Fourteen students were enrolled in the Geo-Field Camp course for the May 2024 semester, including three dual-degree students from Institute Teknologi Sepuluh Nopember (ITS), Indonesia. These students participated in all components of the study, including pre-fieldwork activities, H5P-based classroom learning, and the actual field camp at Gunung Jerai and Merbok, Kedah. The students' participation was tracked through both pre- and post-camp surveys and assessments.

Pre-Fieldwork Activity

The pre-fieldwork activities (Figure 2) were conducted at the UTP GRG and focused on simulating real-world fieldwork experiences. These activities provided students with an opportunity to gain hands-on experience before entering the actual field environment, ensuring they were familiar with essential field

techniques. These activities included key field techniques such as:

1. ***Traversing a river***: Students practised navigating river environments, which is a common scenario in fieldwork.
2. ***Mapping rock distributions:*** Students mapped the geological features of the GRG site to develop their observational and mapping skills.
3. ***Measuring strike and dip:*** Students measured the strike and dip of bedding planes using field equipment.
4. ***Rock characterisation:*** Students characterised rock occurrences and identified various geological formations.





Figure 2 Physical simulation was conducted at the GRG as part of the pre-fieldwork activities to enhance students' understanding of geological concepts and field techniques in preparation for their application during real-world fieldwork

Classroom-Based Interactive Learning

In the classroom setting, H5P tools were utilised to complement the pre-fieldwork activities. These H5P activities were strategically implemented to promote engagement and active participation in learning. Students were encouraged to collaborate with their peers, share ideas, and solve problems collectively. H5P tools also provided flexibility, allowing students to revisit and explore learning materials at their own pace, enhancing knowledge retention. Four H5P techniques were integrated into the curriculum (Figure 3).

Mind-map Presentation

This activity involved students creating and presenting a visual representation of their understanding of key geological concepts and fieldwork techniques through a structured mind map (Figure 3A). The purpose of this activity was to encourage active learning, foster collaborative problem-solving, and help students visualise connections between geological processes and field techniques. The presentations were followed by a peer feedback session, where other students could ask questions, suggest improvements, or highlight areas for further exploration.

Crossword Puzzles

Crosswords were used to reinforce geological terminology and key concepts in a fun and interactive manner. By filling in several terms, students enhanced their retention of vocabulary related to geology and field techniques (Figure 3B). The activity was conducted as a lesson-learning activity in both virtual and physical crosswords exercises in the classroom.

Fill-in-the-Blanks Exercises

These activities were designed to test students' recall and application of geological principles learned in class (Figure 3C). This tool helped ensure that students could remember and apply core concepts learned during the course.

Interactive Video

An interactive video (Figure 3D) was created after the actual fieldwork to recall the geological fieldwork scenarios and key findings from the field investigation, allowing students to interact with the content through embedded questions and tasks. At the end of the video, students summarise the fieldwork, key knowledge, and skills that they have obtained and experienced during the course.

Data Collection and Analysis

The data were analysed to determine the impact of the integrated pre-fieldwork and H5P-based learning on students' engagement, knowledge retention, and understanding of geological concepts. The effectiveness of the Interactive learning approach was evaluated using a combination of quantitative and qualitative data collection methods (Figure 4A and 4B).

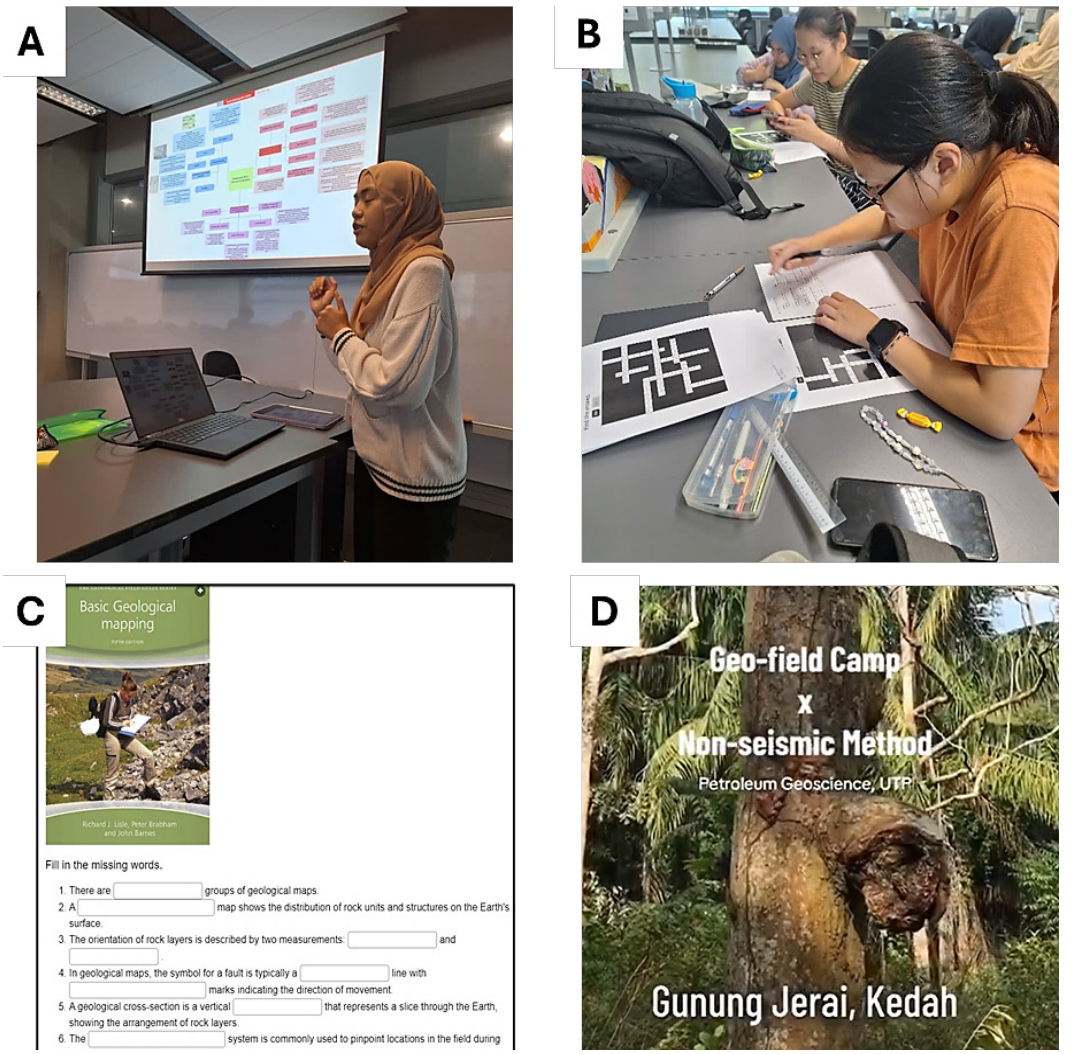


Figure 3 H5P tools and activities in the classroom setting were conducted to complement the pre-fieldwork activities

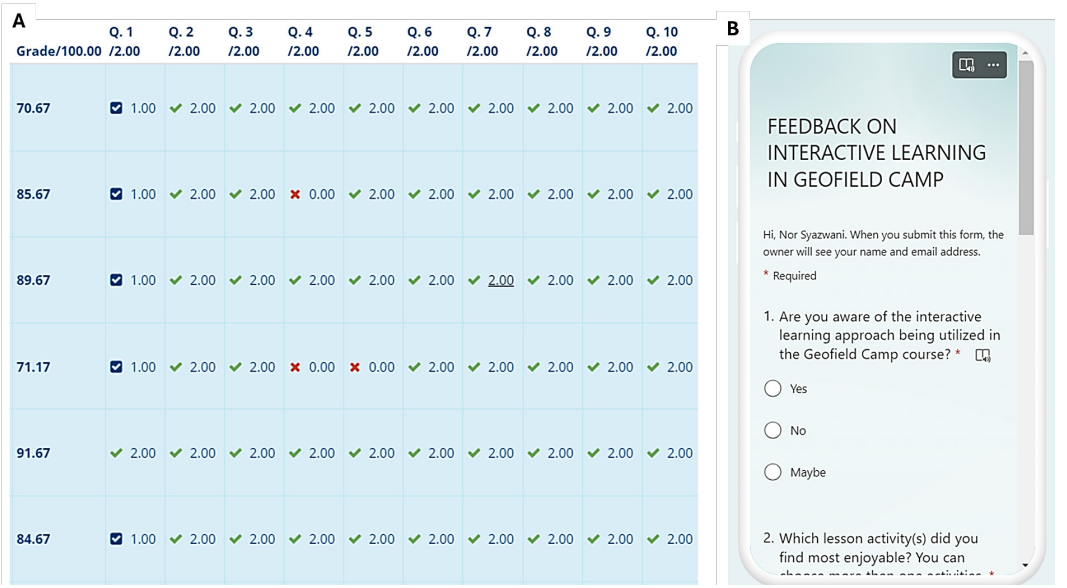


Figure 4 Quantitative and qualitative data collection methods using pre-test, post-test and feedback form to determine the impact of the integrated pre-fieldwork and H5P-based learning

Pre- and Post-fieldwork tests

Quantitative analysis was conducted on pre- and post-fieldwork tests (Figure 4A). Students completed tests before and after the field camp to assess changes in their knowledge, confidence, and readiness for fieldwork. At different course stages, students were administered tests on geological concepts and field techniques to measure knowledge retention.

Student Feedback and Focus Group Discussions

Qualitative feedback was gathered from students through surveys and focus group discussions (Figure 4B). This feedback was used to understand students' perceptions of the pre-fieldwork activities and the use of H5P tools in enhancing their learning experience.

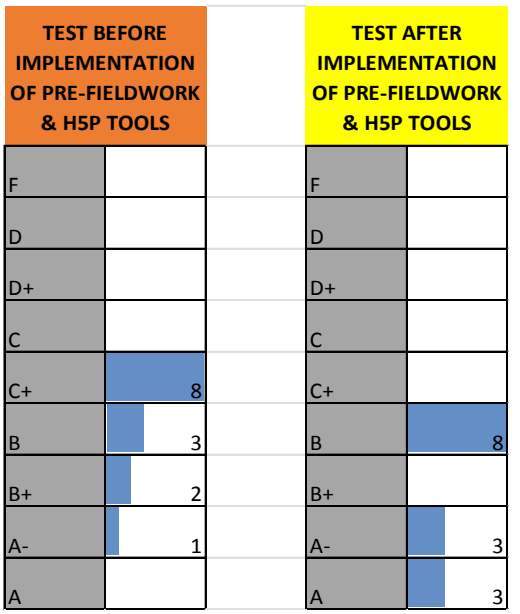


Figure 5 Positive shifts in grades resulted from the tests before and after the implementation of Interactive learning tools

Results and Discussions

The survey results from the Geo-Field Camp course provided insightful feedback on the

interactive learning approach used. Quantitative and qualitative analyses emphasised the Interactive learning nature of H5P tools and their role in simulating real fieldwork, which enhanced learning and teamwork skills crucial for successful fieldwork.

Figure 5 shows the quantitative analysis of pre- and post-fieldwork tests. The results from the tests before and after the implementation of interactive learning tools demonstrate a notable improvement in student performance. Before the integration of interactive learning, a significant portion of the students (8) scored at the C+ level, with only a few achieving higher grades such as B and B+. Notably, no students achieved an A grade. After implementing interactive learning strategies, the distribution of grades shifted positively. The number of students scoring at the B level increased to 8, and students achieved the A- and A grades increased to 6. This shift indicates a clear enhancement in understanding and retention of geological concepts and techniques.

Figure 6 reflects student responses, highlighting awareness and satisfaction with the interactive learning approach and preferences for specific activities, such as physical simulations at the GRG. This feedback underscores the effectiveness of Interactive learning in geoscience education. All 11 respondents were aware of the interactive methods employed, indicating successful communication and implementation of these strategies. This awareness suggests that the participants were well-informed about the course structure and its objectives at the beginning of the semester, which likely contributed to their engagement and understanding.

In terms of enjoyment of the lesson activities, the "Physical Simulation at GRG" was the most favoured, with 55% of participants selecting it as their preferred activity. This preference highlights the effectiveness of hands-on, experiential learning, which seems to resonate well with the learners. Crosswords were enjoyed by 27% of participants, while interactive videos



Figure 6 Qualitative feedback reflects student responses, highlighting awareness and satisfaction with the interactive learning approach and preferences for specific activities, such as physical simulations at the GRG

captured the interest of 18%. Interestingly, the "Fill-in-the-blanks" activity was not chosen by any respondents, suggesting it might not be as engaging or relevant compared to the other options.

Regarding overall satisfaction, a substantial majority of 82% of respondents reported being "very satisfied" with the interactive learning approach, while the remaining 18% were "somewhat satisfied". None of the participants expressed dissatisfaction, indicating a positive reception of the course structure and content. This high level of satisfaction underscores the effectiveness of the interactive approach in meeting the learners' needs and expectations.

The suggestions for improvement were varied, with "No" being a prominent response, suggesting that many participants did not have specific recommendations for changes. However, some keywords like "stimulation", "geofield trip" and "variety of games" were mentioned, indicating areas where participants saw the potential for enhancement. These insights could be valuable in refining the course to further align with learners' interests and preferences. Overall, the feedback reflects a successful implementation of interactive learning, with opportunities for minor adjustments to enhance engagement and effectiveness.

Conclusion

In conclusion, the integration of pre-fieldwork activities and H5P's tools as an Interactive learning approach for the QDB2072 Geo-Field Camp course May 2024 semester has significantly enhanced student engagement, comprehension, and knowledge retention. The interactive and practical nature of these tools not only improved academic performance but also fostered critical skills such as teamwork and critical thinking. Positive student feedback further underscored the effectiveness and satisfaction with this approach, indicating its potential for broader application in other educational contexts.

Acknowledgement

The authors would like to thank the Geoscience Department, Universiti Teknologi PETRONAS, for the opportunity given to conduct the integrated geological fieldwork at the Gunung Jerai and Merbok Area, Kedah, Malaysia, under the department budget (Cost Centre 015BC2-001) and conference fees under the YUTP-FRG (Cost Centre 015LC0-433).

References

Lee, C.H., Yusoff, K., Rahman, N.A., & Ghani, A.A. (2007). Geology and mineralisation of the Gunung Jerai gold mineralisation, Kedah, Malaysia. *Bulletin of the Geological Society of Malaysia*, *53*, 45-59.

Rodriguez, A. & Armellini, A. (2020). Active learning and engagement through H5P: Evaluating the impact on student learning. *Educational Technology & Society*, *23*(2), 110-123.

Enhancing Civil Engineering Education: A Framework for Mobile-Learning and Project-Based Learning Integration

Salmaliza Salleh[*1], Jeena Reji[2], Panos Kloukinas[3]
[1]Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS, Malaysia
[2]Faculty of Engineering and Science, University of Greenwich, United Kingdom
[3]Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Malaysia
[*]salmaliza.salleh@utp.edu.my

Introduction

Mobile learning (M-learning) is a concept that enables learners to engage in educational activities without the constraints of having to be at a fixed, predetermined location (Hockly, 2013), like in a classroom. It takes advantage of lightweight, portable devices such as mobile phones, smartphones and tablets, which can be carried around with relative ease and are used for communication and collaboration (Motiwalla, 2007). M-learning has various attributes, including knowledge building by learners in different contexts, enabling them to construct understandings beyond time or space boundaries and inspiring transformation by guiding what the learner is constructing (Hockly, 2013). It is an effective method for teaching and learning that supports learners' self-organisation, self-direction and personalised learning (Voicu, 2023).

Meanwhile, Project-based Learning (PjBL) involves a specific syntax, which includes reflection, research, discovery application and communication. This approach enables individuals to identify problems and explore them for desirable solutions (Nurhidayah et al., 2021). PjBL is designed to motivate students to learn material found in everyday life while also enhancing their creativity. This enhances their application skills and communication capabilities within or as groups (Guo et al., 2020). It involves an inquiry-based approach that encourages students to develop key skills such as critical thinking, communication, collaboration, and problem-solving. As part of the process, students must plan, create, and present their projects to the teacher and their peers (Aldabbus, 2018). Studies have shown that PjBL can increase student creativity, with survey results indicating that 97.3% of students felt motivated and 94.6% found it easy to understand the lessons (Kim, 2021).

However, research on mobile learning implementation in student-centric pedagogy, such as PjBL, is still limited (Motiwalla, 2007). Most of the existing research has focused on technology, features and teaching strategies of mobile learning (Trifonova, 2003). Pedagogy such as PjBL involves student-centred learning, which requires more active participation from learners to understand concepts. This kind of participatory learning is not always possible through mobile devices due to technical limitations or lack of access. Many educators are also unfamiliar with integrating PjBL within a mobile environment (Sharples, 2020). They hesitated to explore this method further due to its potential complexity or risk involved in trying something new that could disrupt the classroom dynamic if it fails. Thus, this study aims to explore the effectiveness of integrating PjBL methodology with mobile technology and propose its framework in Civil Engineering programmes.

Research Methodology

The methods employed were systematic literature review (SLR) and the distribution of an online questionnaire to civil engineering students from the University of Greenwich's September 2022 intake. The Mobile Project-Based Learning (MPjBL) Framework was then developed from the analysed findings.

Systematic Literature Review

SLR is the primary foundation of secondary data collection in this research, sourced from previously published literature such as research articles, books, reports and online resources pertinent to the subject matter. The process involved utilising databases and institutional library facilities for relevant content search using predetermined keywords associated with M-learning environments integrated with project-based pedagogy specifically towards engineering education context.

Online Survey

An online survey questionnaire was prepared based on the input analysed from the SLR. The aim was to understand the experiences of 52 civil engineering students enrolled in the CIVI 1021 Project Risk Management course regarding their usage of M-Learning environments integrated with PjBL components (MPjBL) during their designated group project for knowledge acquisition purposes. It encompassed questions about their experience, perceived benefits, and potential challenges faced during the MPjBL implementation, along with participant demographics.

Results and Discussions

The study revealed positive experiences with M-Learning and PjBL, as both methods encouraged active participation and self-directed learning. However, challenges such as physical space constraints, a shortage of skilled personnel, and time-consuming MPjBL activities were noted. To address these issues, an MPjBL framework has been developed to integrate the mobile technology and PjBL principles, emphasising flexibility, collaboration, and enhanced engagement. The framework effectively mitigated technical challenges by offering structured support, fostering collaborative learning, and promoting skills development, leading to improved learner outcomes and satisfaction in mobile-enabled project-based environments.

Experiences with M-Learning and PjBL

Figure 1 shows the summary feedback from the respondents on their experience with M-Learning and PjBL. 81.5% of the respondents have previously adopted mobile learning technologies in their courses, indicating a high level of familiarity with this learning mode.

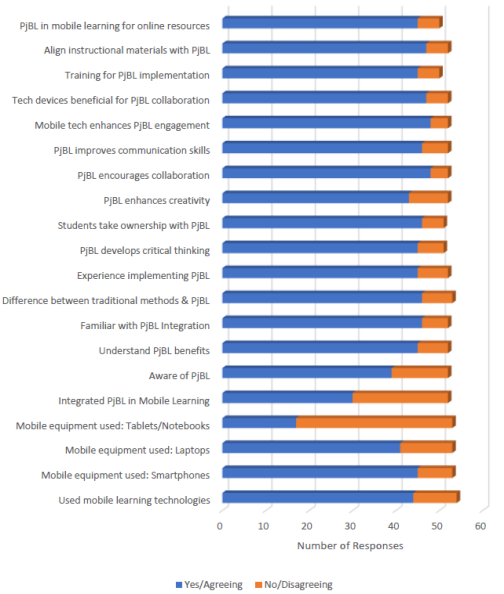


Figure 1 Students experiences with M-Learning and PjBL

Among the devices used, smartphones were the most popular, with 84.9% of respondents having used them. 92.3% of respondents also believe integrating mobile technology in PjBL activities can enhance student engagement.

Challenges of MPjBL

The survey results shown in Figure 2, there is a notable acknowledgement among the respondents regarding the challenges associated with the MPjBL method. 81% believed that physical space constraints would challenge the effective implementation of MPjBL, 75% of the respondents feel a shortage of skilled personnel to guide students on MPjBL, while 68% of respondents concur that MPjBL activities can be more time-consuming than traditional teaching methods.

Development of MPjBL Framework

Based on the literature review findings and questionnaire feedback, a framework was designed, as shown in Figure 3. It outlines a practical approach to blending PjBL with M-learning. By identifying the learning needs, selecting relevant projects, and creating a strong technology base, we can ensure a solid start to the integration. Infrastructure compatibility across devices, cloud integration, and security measures assure students' access to resources without trouble. Building a digital resource hub and using collaborative tools foster engagement. Physical space is not necessary. Adding interactive elements spices up the class's learning. For project execution, dividing tasks, setting milestones, and encouraging teamwork keep things on track. Real-time feedback adds a helpful touch for the students. Assessment involves digital portfolios, peer reviews, and clear rubrics, gauging their knowledge and soft skills. Reflection and iteration through mobile journals and project improvements enhance learning. Presentation and peer-sharing sessions can be enriched by interactive mobile tools. Continuous growth shall be backed by educator training through mobile modules and sharing via community forums. Evaluation happens through mobile surveys and analytics to refine the approach continuously.

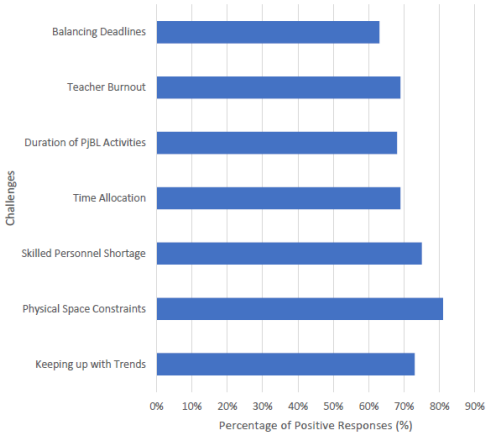


Figure 2 Challenges of MPjBL method

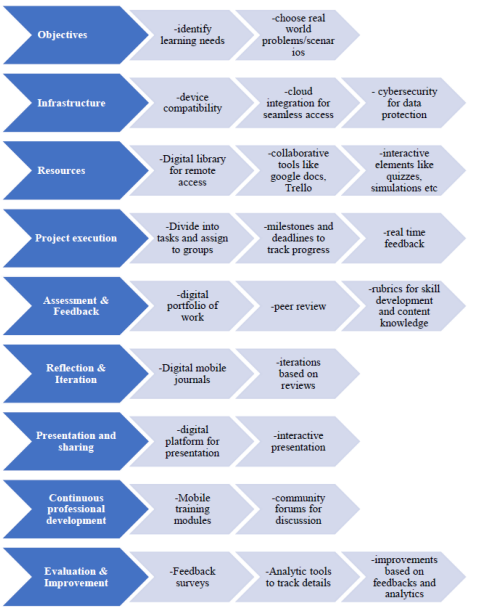


Figure 3 MPjBL Framework

Conclusion

The integration of Mobile Learning (M-Learning) and Project-Based Learning (PjBL) presents a dynamic approach to enhancing engineering education. By integrating M-Learning with PjBL, students benefit from increased engagement, improved critical thinking, and strengthened problem-solving and collaboration skills. This strategy aligns with the practical needs of the industry, ensuring that students gain relevant, hands-on experience. However, challenges such as limited infrastructure and the need for teacher training and equitable access remain obstacles to effective implementation. To address these, the developed MPjBL framework suggests using mobile-friendly tools and interactive e-learning modules to enrich the learning process. By addressing these challenges and embracing recommended innovations, educators can fully harness the potential of technology, fostering an enriched and future-ready engineering education.

Acknowledgement

Special thanks to the Department of Civil Engineering, University of Greenwich, United Kingdom and Universiti Teknologi Malaysia for collaborating on this research.

References

Aldabbus, S. (2018) Project-Based Learning: Implementation & Challenges, *International Journal of Education, Learning and Development*, *6*(3), 71–79.

Guo, P., Saab, N, Post, L. S, & Admiral W. (2020). A review of project-based learning in higher education: Student outcomes and measures, *International Journal of Educational Research,* 102, 101586. Doi:10.1016/j.ijer.2020.101586.

Kim, Y. (2021). The Problem/Project-Based Learning (PBL/PjBL) at Online Classes, *International Journal of Advanced Culture Technology*, *9*(1), 162–167. Doi:10.17703/IJACT.2021.9.1.162.

Nurhidayah, I. J., Wibowo, F. C., & Astra, I. M. (2021). Project Based Learning (PjBL)learning model in science learning: Literature Review. *Journal of Physics: ConferenceSeries*, *2019*(1). Doi: 10.1088/1742-6596/2019/1/012043

Hockly, N. (2013). Mobile learning, *ELT Journal*, *67*(1), 80–84. Doi: 10.1093/elt/ccs064

Motiwalla, L. F. (2007) Mobile learning: A framework and evaluation, *Computers and Educatio*n, *49*(3), pp. 581–596. doi: 10.1016/j.compedu.2005.10.011

Sharples, M. (2020). Big Issues in Mobile Learning. *Mobile Learning Initiative*, *21*(1), 1–9. http://journal.um-surabaya.ac.id/index.php/JKM/article/view/2203

Trifonova, A. (2003). *Mobile learning-review of the literature* (Technology Report No DIT03009), Department of Information and Communication Technology, University of Trento

Voicu, M.-C.; Muntean, M. (2023) Factors That Influence Mobile Learning among University Students in Romania. *Electronics*, *12*(4), 938. Doi:10.3390/electronics.12040938

Empowering Future Leaders: The Transformative Impact of Action-Based Learning at INCEIF

Zulkarnain Muhamad Sori*, Nurshakira Hairuddin, Asmawi Asari, Mohd Norhisham Mohamad
Action Based Learning Unit, INCEIF University, Malaysia
*abl@inceif.edu.my

Introduction

Action-Based Learning (ABL) transforms passive and lecture-centered learning into an active, student-driven experience. At INCEIF University, students collaborate with industry partners in addressing real-world issues that require the application of theoretical concepts into practical implementation. This hands-on approach fosters critical thinking, teamwork, time management, adaptability and leadership skills that are relevant in the workplace. This paper aims to showcase how ABL pedagogy at INCEIF fosters transformative educational experiences by integrating theory and practices. Through ABL, students and industry partners work hand in hand to solve industry issues and benefit from each other.

Literature Review

The shift from traditional lecture-based education towards a student-centred approach has gained attention, especially in fields requiring practical skills alongside theoretical knowledge. Kolb's (1984) experiential learning model suggests that practical assignment enhances the retention of information. Lave and Wenger (1991) argue that learning through doing is the best learning approach when students are empowered in their learning journey. Furthermore, literature has documented that ABL is an effective pedagogy that fosters critical thinking and problem-oriented thinking, which are necessary in today's rapidly changing world (Prince, 2004; Hattie, 2012). According to Marton and Säljö (1976), group work practices are important not only to the Islamic finance sector but also to other sectors as well. Another critical aspect of ABL is self-directed learning, which allows students to practice reflectively.

Methodology

INCEIF's ABL methodology immerses students in a dynamic hands-on approach to learning. The process begins with pre-project preparation, where students participate in skill development workshops that align with course learning objectives. Students are then grouped into teams to work on real-world projects with industry partners from various industries, including government agencies, Government-



Figure 1 A project on Sustainable Tourism and Muslim Friendly Hospitality

Linked Companies (GLCs), private companies, non-profit institutions, Islamic Financial institutions and Islamic Social Finance institutions. Additional skill development workshops run alongside the projects, ensuring students acquire practical skills.

The process involves several stages: project briefing with mentors and industry partners to clarify objectives, research and data collection, problem definition and analysis, and solution development tailored to industry needs. Regular feedback and iteration sessions with mentors ensure refinement. The process concludes with a final presentation, a report to industry partners, and a compilation of mentor and industry partner assessments. Post-project, students reflect on their experiences to identify areas for improvement.



Figure 2 A project on Green City Terminal propels economic growth to new heights

Compared to the traditional model, ABL promotes greater engagement, skill acquisition, and practical problem-solving, demonstrating the tangible benefits of experiential education for students and industry partners.

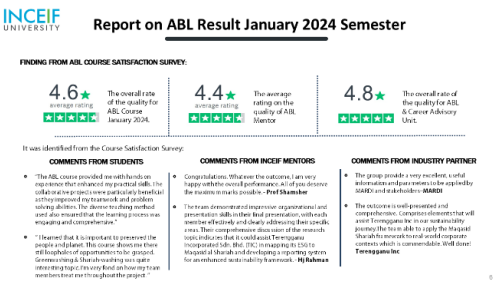


Figure 3 ABL Projects Flow

Results

The Impact of The ABL Pedagogy towards Students and Industry Partners

Following the implementation of this student-centred approach, a survey was conducted to gauge the success of ABL towards students and industry partners. Below are the comments received from the stakeholders.


INCEIF UNIVERSITY

Report on ABL Result January 2024 Semester

FINDING FROM ABL COURSE SATISFACTION SURVEY:

4.6★ average rating — The overall rate of the quality for ABL Course January 2024.

4.4★ average rating — The average rating on the quality of ABL Mentor

4.8★ — The overall rate of the quality for ABL & Career Advisory Unit.

It was identified from the Course Satisfaction Survey:

COMMENTS FROM STUDENTS

- "The ABL course provided me with hands-on experience that enhanced my practical skills. The collaborative projects were particularly beneficial as they improved my teamwork and problem-solving abilities. The diverse teaching method used also ensured that the learning process was engaging and comprehensive."
- "I learned that it is important to preserved the people and planet. This course shows me there still loopholes of opportunities to be grasped. Greenwashing & Shariah-washing was quite interesting topic. I'm very fond on how my team members interact with me throughout the project."

COMMENTS FROM INCEIF MENTORS

- Congratulations. Whatever the outcome, I am very happy with the overall performance. All of you deserve the maximum marks possible - **Prof Shamsher**
- The team demonstrated impressive organizational and presentation skills in their final presentation, with each member effectively and clearly addressing their specific areas. Their comprehensive discussion of the research topic indicates that it could assist Teresgquna Incorporated Sdn. Bhd. (TIC) in navigating its Shariah Maqasid al Shariah and developing a reporting system for an enhanced sustainability framework. - **Hj Rahman**

COMMENTS FROM INDUSTRY PARTNER

- The group provide a very excellent, useful information and pure reviews to be applied by MARDI and stakeholders- **MARDI**
- The outcome is well-presented and comprehensive. Comprises elements that will assist Teresgquna Inc in our sustainability journey the team able to apply the Maqasid Shariah to research to real world corporate contexts which is commendable. Well done! **Teresgquna Inc**

Figure 4 Sample findings from the ABL course satisfaction survey



Figure 5 A project on crafting impact assessments for social enhancement



Figure 6 A project on Islamic Social Finance at Smart SBB

For industry partners, ABL offers a unique opportunity by providing fresh perspectives that enable them to tap into the growing talent pool. Through the ABL collaborative approach, partners receive bespoke recommendations that directly address their needs. This partnership fosters valuable academic-industry connections and delivers impactful insights and solutions at a significantly lower cost than traditional consultancy without compromising the quality of outcomes.

Alongside the essential skills the students gained throughout the ABL journey, they also have the advantage of strengthening their employability by working on a real-world project. This hands-on experience not only enables them to step into their careers with an established project portfolio but also build meaningful industry connections — a valuable asset as they begin their professional paths.

Conclusion

The ABL at INCEIF provides a conducive learning experience for students to equip themselves with the hard and soft skills needed for their future endeavours. At the individual level, students gained experience through self-awareness, empowerment in making decisions and enhanced leadership skills. They have experience in 360-degree communication and collaboration with team members, academics and industry mentors. In this context, the ABL at INCEIF allows students to address industry problems by employing resources at hand and enhancing required soft and hard skills. Each project helps students investigate concerns and cultivate skills related to problem-solving, ethical consideration, and sustainability, which would be requisite in career development. Working with industry partners provides students with hands-on experience that enhances their employment prospects and provides them with solution portfolios.



Figure 7 A Project on bridging the financial divide for Malaysian B40 and M40 Communities



Figure 8 A project on halal sustainability supply chain

For industry partners, ABL extends research-oriented solutions to problems such as financial inclusion and sustainable development without exposing them to considerable risks. This interaction of student learning and development with industry practice is a win-win for both the students and the businesses, opening doors to evolution in industry.

Acknowledgement

We extend our heartfelt thanks to INCEIF Management, the ABL Committee, INCEIF Faculty members, industry partners, students, and INCEIF community for their invaluable contributions and support.

References

Hattie, J. (2012). *Visible Learning for Teachers: Maximizing Impact on Learning*. New York: Routledge.

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, New Jersey: Prentice-Hall.

Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge, United Kingdom: Cambridge University Press.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I – Outcome and process. *British Journal of Educational Psychology*, *46*(1), 4–11.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223-231.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action.* New York: Basic Books.

Visualising Trigonometric Applications through Digital Comics

Noraini Jamaludin
Centre for Foundation Studies, Universiti Teknologi PETRONAS, Malaysia
noraini.jamaludin@utp.edu.my

Introduction

In today's digitally driven world, integrating technology in education is essential for transforming traditional teaching methods into more engaging and effective learning experiences. Mathematics, particularly trigonometry, is often perceived as abstract and challenging for students. Bridging the gap between theoretical concepts and real-world applications is crucial to enhancing students' understanding and appreciation of the subject.

This paper explores an innovative approach to teaching trigonometry by utilising digital comic strips as a learning tool. By presenting trigonometric applications through a visually engaging format, the assignment encourages students to translate mathematical ideas into real-life scenarios creatively. This approach taps into visual learning strategies, where complex concepts are broken down into easily digestible narratives, making them accessible and relatable.

The assignment, conducted as part of the assessment component in the Mathematics I course, tasked students with designing digital comic strips that illustrated real-world trigonometric applications. Using Canva for design, students created dynamic digital comic strips that not only demonstrated their understanding of trigonometry concepts but also showcased their ability to apply those concepts practically. The focus of this paper is to examine the role of digital comics in visualising and applying trigonometric concepts, highlighting the correlation between technology, creativity, and mathematics. Through analysis of student assignment marks and feedback from judges, this study aims to evaluate how effectively digital comics can foster both engagement and comprehension of trigonometry. By integrating visual storytelling and digital innovation, this assignment offers a fresh perspective on learning complex mathematical concepts in a real-world context.

Related Work/Literature Review

The integration of digital tools in education has revolutionised the teaching and learning process, particularly in subjects like mathematics, where abstract concepts can be challenging to comprehend. Technology-enhanced learning environments have been shown to improve student engagement and facilitate a better understanding of mathematical principles (Muhazir & Retnawati, 2020; Huda, 2019; Del Zozzo & Santi, 2023). This approach bridges the gap between theoretical mathematics and real-life applications, making complex concepts more accessible.

One emerging tool is the use of comics in educational contexts. Comics combine visual and narrative elements, creating a medium that

can simplify the understanding of difficult topics (Arilaksmi et al., 2019). Educational comics have emerged as a powerful tool for conveying complex mathematical concepts to students in a dynamic and engaging manner. Research has consistently demonstrated that these visual narratives can effectively embed mathematical ideas within stories that students find relatable and captivating (Azizi & Fauzan, 2020). The visual representation of mathematical problems in comic format allows learners to better grasp abstract ideas like trigonometric functions by relating them to practical, real-world scenarios. Additionally, the incorporation of compelling narratives and characters in these comics helps students stay engaged and motivated throughout the learning process.

In mathematics education, visual aids have been employed to enhance understanding. Digital comics extend this concept by offering interactive and customisable learning experiences. For example, platforms like Canva enable students to create digital comic strips, allowing them to visualise and narrate mathematical problems creatively. Such tools have been praised for fostering active learning environments where students construct knowledge through collaboration and feedback (Meilantifa et al., 2019).

Specifically, in trigonometry, digital comics can play a crucial role in demonstrating real-life applications of concepts like sine, cosine, and tangent. By situating trigonometric problems within everyday scenarios, such as calculating heights, angles, or distances in architectural designs, students can visualise how these concepts function in the real world Nurfitriyanti et al., 2020). This approach helps students move beyond rote learning, allowing them to see the practical significance of trigonometry.

The use of digital comics in teaching mathematics, particularly trigonometry, has garnered increasing attention in recent years. Research suggests that incorporating visual storytelling can enhance student engagement and motivation by providing a relatable context for grasping complex mathematical concepts. (Meilantifa, Soewardini, & Supratiwi, 2019).

However, the actual educational value of this approach remains a subject of debate. Some critics argue that digital tools may make learning more engaging but do not always ensure a deeper understanding of the content. Therefore, assessing student outcomes and ensuring that digital comics support comprehensive learning is essential.

In summary, the use of digital comics in teaching trigonometry offers a promising avenue for enhancing student engagement and contextualising mathematical concepts. However, more research is needed to explore their impact on long-term academic performance and conceptual mastery.

Research Methodology

This project used a two-stage approach to incorporate real-life trigonometric concepts into digital comic strips, leading to the Math Comic Challenge (MCC). The stages were carefully planned and executed over 12 weeks. Stage 1 focused on executing assignments involving the creation of digital comic strips and Stage 2 featured the MCC to showcase and appreciate students' work.

Stage 1: Assignment Execution (Weeks 1–10)

Objective: To achieve the second Course Learning Outcome (CLO2) of Mathematics I (FBM0015), contributing 12% to coursework marks; and to provide an innovative platform for students to understand and apply trigonometric concepts through digital comic creation.

Week 1-3 Planning Stage
Assignment guidelines and rubrics were designed to focus on the clarity of trigonometric concepts, relevance to real-life scenarios,

case study background, problem statements, mathematical calculations, and comic strip storytelling.

Week 4 Assignment Grouping
Students were grouped into teams to ensure diverse learning environments. In January 2024, 651 students enrolled in Mathematics I were divided into 8-9 assignment groups by their respective lecturers.

Week 5 Assignment Briefing
Detailed assignment instructions were provided to students by their individual lecturers. The assignment was divided into two parts:

Part A: Students created digital comic strips on real-life applications of trigonometric concepts using Canva. Each comic had to present a specific concept, a real-life scenario, and the accompanying mathematical calculations.

Part B: Each group produced a summary video explaining the comic strip, highlighting the problem statement, mathematical approach, and solution.

Week 6-8: Brainstorming and Development
Teams engaged in brainstorming sessions and created their comics, with scaffolding support from lecturers to ensure students stayed on track.

Week 9: Assignment Compilation
Groups finalised both Part A (comic strip) and Part B (summary video).

Week 10: Assignment Submission
Students submitted their work for evaluation. Submissions were evaluated by lecturers based on the rubric, covering six key criteria: clarity of trigonometric concepts, relevance to real life, background of case study, problem statement, mathematical calculations, and storyline.

Stage 2: Math Comic Challenge (MCC) (Weeks 11–12)

Objective: To motivate and engage students by highlighting the relevance of trigonometric concepts in everyday life through the creation of comic strips.

Week 11: Announcement of Finalists
Based on assignment scores, the top-performing groups were announced as finalists for the MCC. A total of 18 groups were selected to compete in the final round. Judges, comprising technical and non-technical experts, were provided with student submissions one week before the competition to prepare for their evaluation.

Week 12: Judging and Award Ceremony
Finalists participated in a live Q&A session with the panel of judges. Groups were evaluated using the same rubric, emphasising creativity, technical accuracy, and storytelling. Awards were presented in the following categories to acknowledge and reward their hard work and creativity:

a. The 6 Best Comic Design and Content
b. The 12 Consolation Prizes

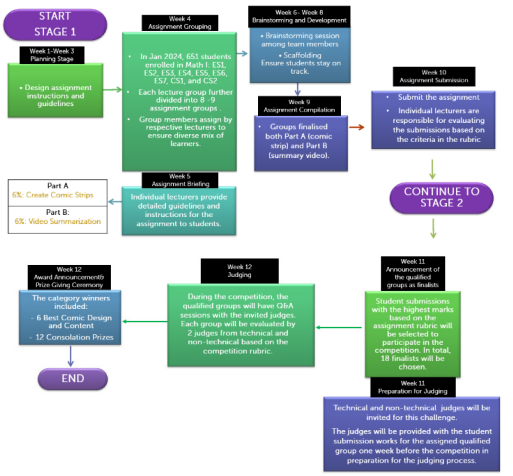


Figure 1 Two-stage approach: digital comic assignment and math comic challenge

Results and Discussions

Stage 1: Assignment Execution Success Measures

The success of Stage 1 was evaluated through two key measures: group assignment marks distribution and the categorisation of trigonometric applications.

Group Assignment Marks Distribution

Figure 2 illustrates the distribution of assignment marks achieved by a randomly selected sample of 27 groups in the Mathematics I course, based on a total score of 12%. The data shows that 70% of the groups scored between 11.5 and 12.00, indicating a high understanding of trigonometric concepts. Additionally, 15% of the groups scored between 11.0 and 11.5, 11% scored between 10.5 and 11.0, and 4% scored between 10.0 and 10.5. This distribution highlights the overall success of students in effectively engaging with and applying trigonometric concepts through the creation of digital comic strips. The marks were awarded based on a rubric that outlined evaluation criteria, including problem statement, explanation of the trigonometric concept, relevance to real life and mathematical calculations.

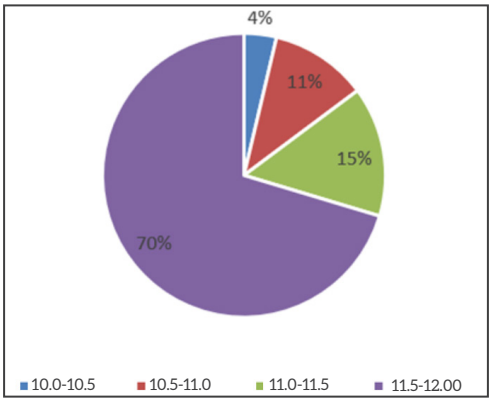


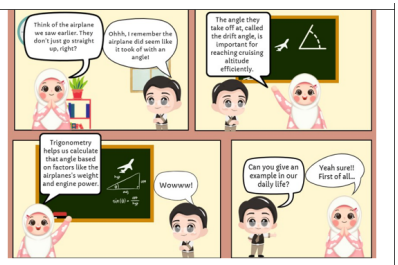
Figure 2 Group assignment marks distribution

Categorisation of Trigonometric Applications

To illustrate the diverse applications of trigonometry, students selected a variety of real-life scenarios for their comic strips. Table 1 presents random samples of the categories chosen by the students, along with the titles of their comic strips and brief descriptions of how trigonometric concepts were applied in each context. This variety demonstrates the students' ability to connect mathematical concepts to different fields, showcasing their creativity and critical thinking skills.

Table 1 Random samples of trigonometric applications in student comic strips

Architecture and Structural Engineering	 This comic depicts a dialogue about the variety of roof designs, highlighting how trigonometric functions can analyze the relationship between height and horizontal span, showcasing practical applications in architecture.
Forensic Science and Crime Scene Investigation	 This comic illustrates a discussion on crime scene analysis, where characters use trigonometric concepts to determine the shooter's height based on the angle of the bullet's trajectory and the distance from a nearby hotel.

Mountain Climbing	 This comic depicts climbers discussing their ascent up a mountain and their curiosity about the height they've climbed. They consider using trigonometric principles to determine their altitude based on the angle of elevation and the distance traveled.
Aviation and Flight Mechanics	 This comic features a conversation about airplanes and the significance of trigonometry in aviation. It explains how trigonometric calculations, particularly the drift angle during takeoff, are essential for determining efficient ascent based on the airplane's weight and engine power.

Stage 2: Math Comic Challenge (MCC) Success Measures

The success of Stage 2 was assessed through two main criteria: judges' feedback during the presentation session and the recognition of outstanding achievements during the award ceremony.

Judges' Feedback

Feedback from the panel of judges, who evaluated the finalists during the Q&A session of the presentation, emphasised several key strengths in the comic submissions. The judges noted that the problem statements presented in the comics were clear and directly relevant, effectively demonstrating the real-life application of trigonometric concepts. Participants thoroughly explained these concepts, showcasing the complexity and creativity of the mathematical calculations involved. Additionally, the integration of mathematical content with the storyline was commendable, making it accessible for a lay audience to understand trigonometric principles through the comics. This feedback reinforces the students' hard work and dedication and offers constructive insights for future projects, highlighting areas for improvement and encouraging continuous development in their mathematical storytelling skills.

Figure 3 shows the Net Satisfaction Score (NST) for the clarity of the problem statement, which received a score of 33. This suggests that while clarity is recognised in the problem statement, it may not be overwhelmingly positive. This score indicates that there is still room for improvement.

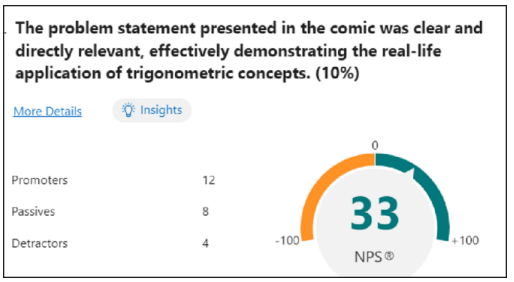


Figure 3 Clarity of the problem statement

Figure 4 shows the NST for the explanation of trigonometric concepts, which scored 63. This score indicates strong satisfaction with how well participants explained these concepts. This suggests that the explanations were effective and resonated well with the audience, showcasing a solid understanding of the concepts.

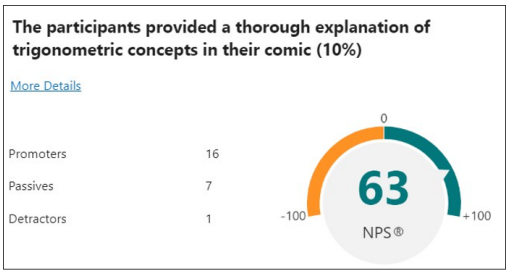


Figure 4 Explanation of trigonometric concepts

Figure 5 shows the NST for integrating mathematical content with the storyline, which scored 41. This indicates moderate satisfaction, suggesting that while the integration was generally good, areas could be improved for better understanding. Gathering feedback on specific points where integration faltered could guide enhancements in future submissions.

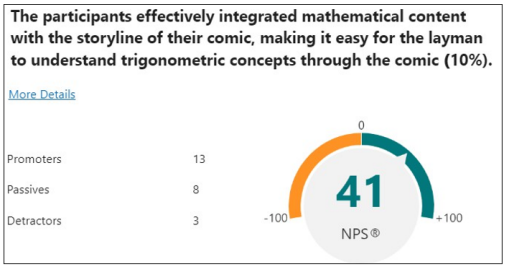


Figure 5 Integration of mathematical content with storyline

Recognition of Outstanding Achievements

The competition concluded with an award ceremony celebrating the finalists' achievements, as shown in Figure 6. Awards were presented for the six best comic designs and content, along with 12 consolation prizes, recognising the exceptional creativity and comprehension demonstrated by the winners.

This recognition underscores the success of the MCC in fostering a competitive spirit among students and promoting excellence in applying trigonometric concepts, motivating them to explore and innovate within the field of mathematics.



Figure 6 Recognition of top six Comic Design Winners

Conclusion

In conclusion, this study underscores the effectiveness of digital comics as a transformative educational tool in teaching trigonometric applications. By engaging students in the creative process of comic strip design, the findings reveal a notable enhancement in their comprehension of trigonometric concepts and their relevance to real-world scenarios. Analysing student assignments and judges' feedback highlights the importance of integrating technology into mathematics education, facilitating active learning and creative expression.

Moreover, the incorporation of digital comics not only makes trigonometry more accessible but also fosters a deeper appreciation for the subject. As education evolves in a digital landscape, leveraging innovative methods can significantly enrich the learning experience, preparing students to apply mathematical principles effectively in everyday situations.

Acknowledgement

The authors would like to thank the Center for Academic Excellence (CAdEx) at Universiti Teknologi Petronas for providing this platform to enhance innovative teaching practices. I also appreciate the opportunity to participate in the Teaching and Learning Innovation Festival 2024 (TLIF 2024), where we can share transformative ideas in education.

References

Muhazir, A., & Retnawati, H. (2020). The teachers' obstacles in implementing technology in mathematics learning classes in the digital era. *Journal of Physics: Conference Series, 1511*(1), 012022. Doi:10.1088/1742-6596/1511/1/012022

Huda, M. (2019). The problematic: Teachers' pedagogical ability in using technology on mathematics learning of junior high school. *Journal of Physics: Conference Series, 1200*(1), 012009. Doi:10.1088/1742-6596/1200/1/012009

Del Zozzo, A., & Santi, G. (2023). Transitions between domains of activity as "domestications of the eye" for the learning of mathematics with GGBot. *Digital Experiences in Mathematics Education, 9*(1), 3-22. Doi:10.1007/s40751-023-00124-7

Arilaksmi, N. P. G., Ummah, S. K., & Utomo, D. P. (2019). Development of mathematical comics with an Indonesian cultural background on comparative materials. *AIP Conference Proceedings, 2194*(1), 020008. Doi:10.1063/1.5139740

Azizi, N., & Fauzan, A. (2020). Improvement of students' activities and learning outcomes in mathematics through comics-based on student worksheets of seventh grade Islamic junior high school in Padang. *Journal of Physics: Conference Series, 1554*(1), 012028. Doi:10.1088/1742-6596/1554/1/012028

Meilantifa, M., Soewardini, H. M. D., & Supratiwi, R. A. (2019). Mathematical comics on class X trigonometry learning. *Journal of Physics: Conference Series, 1175*(1), 012013. Doi:10.1088/1742-6596/1175/1/012013

Nurfitriyanti, M., Suhendri, H., & Nurhayati. (2019). Effectiveness of mathematical comics as the development of teaching material. *Proceedings of the 1st International Conference on Folklore, Language, Education and Exhibition (ICOFLEX 2019)*, 219–224. Atlantis Press.

Enhancing AI Learning Outcomes Through Peer-Coaching in Flipped Classrooms: A Controlled Study

Ramani Kannan[*1], Khairul Nisak Bt Md Hasan[1], Mohammed Isam Al-Hiyal[1] , Vishal Jain[2]
[1]Department of Electrical and Electronic Engineering, Universiti Teknologi PETRONAS, Malaysia
[2]Department of Computer Science and Engineering, Sharda University, Greater Noida, U.P., India
[*]ramani.kannan@utp.edu.my

Introduction

Artificial intelligence (AI) education is increasingly recognised as a critical component of modern curricula, enabling students to interact with and shape the future of technology effectively. In learning, AI includes theoretical knowledge and practical skills designed to enable learners to understand the ideas behind AI technologies and apply them innovatively across a wide range of fields (Jin, 2023).

The introduction of artificial intelligence into educational settings has seen the invention of new ways of teaching and learning subjects. The flipped classroom model is among the considerable developments in this regard (Li, 2022). This model inverts traditional learning by delivering instructional content, often online, outside the classroom (Stohr, Demaziere & Adawi, 2020). The flipped classroom environment allows the students to participate in hands-on learning activities. In contrast, the traditional classroom models are usually interactive, enabling the students to ask questions and participate in activities to learn new material. However, traditional classrooms sometimes consume a lot of time to complete a topic (Saira et al., 2021).

Literature Review

Digital online platforms have recently been used in schools to improve students' skills and make it easier to equip themselves with knowledge. These platforms have introduced a new teaching strategy, the 'flipped classroom'. The flipped classroom is a teaching approach in which students first engage with new content at home through videos or reading before participating in interactive and collaborative activities in the classroom. This method, also known as flipped teaching, allows students to access learning materials and instructions independently, which has proven particularly beneficial during the pandemic. The concept of the flipped classroom, first described by Garrett and Honeycutt (2013) and Foertsch et al. (2002), reverses the traditional learning environment by delivering instructional content outside of the classroom and engaging students in interactive activities during class time. Subsequent studies by Magana et al. (2022) and Niesen et al. (2018) have quantitatively demonstrated that this approach not only enhances student performance but also significantly increases engagement and interaction within the classroom.

Peterson (2015) and Shinaberger (2017) further investigated the cognitive impacts of this model, noting improved application and analysis skills among students who prepared ahead of class time. Additionally, Xu et al. (2019) explored the integration of peer coaching into the flipped classroom, revealing that it fosters a more collaborative and supportive learning environment crucial for the professional development of students. Peer

coaching involves a coach and a peer, where the coach helps and gives feedback to the peer. They can also expand, refine, and build new skills, share ideas, teach one another, conduct classroom research, or solve problems in the workplace (Hohensee & Lewis, 2018). Some elements make up peer teaching, which occurs between two or more colleagues who reflect on current practices; this looks like giving feedback. The second part is about building skills. The third part is about sharing ideas and teaching one another. The last part is about solving problems in the workplace, which reminds us of the importance of soft skills and collaboration in solving future challenges (Hagen & Tani, 2017).

The previous studies mentioned above underscore the potential of flipped classrooms integrated with peer coaching but also highlight areas needing further investigation, particularly in systematic implementation and measurable outcomes. Our study aims to address these gaps by providing empirical evidence on the specific impact of peer coaching in flipped classroom settings on student satisfaction and academic performance. This study aims to fill this gap by comparing the effectiveness of a peer-coaching flipped classroom model against a conventional one in a controlled educational setting.

Research Methodology

This section clarified the approach and procedures used in the study to compare the effectiveness of peer coaching in a flipped classroom with a conventional flipped classroom approach. It also explained the participants, data collection methods and data analysis techniques used in the study.

Participants

This study was conducted with students taking the Introduction to Artificial Intelligence course at Universiti Teknologi Petronas in September 2023.The students were divided into two main groups. The experimental group consisted of 50 students divided into six subgroups (EG1 to EG6), each led by a leader responsible for organising and managing the members. Besides, the control group, consisting of 51 students divided into five subgroups (CG1-CG5), experienced a conventional flipped classroom approach compared to the experimental group.

Both study groups participated and engaged with the same teaching materials, such as videos and notes from the lecturer, before the teaching sessions. The teaching materials were selected from different subject areas to teach the basic concepts of AI. This included practical online programming and machine learning problem-solving courses aligned with the course objectives. Both groups were involved in the study to compare the learning outcomes and effectiveness of the peer coaching method with the conventional flipped classroom approach. The aim was to determine whether peer coaching improves understanding and engagement in learning AI concepts in fourth-year engineering students.

Data Collection

The performance of students was measured through tests and assignments conducted both before (pre-phase) and after (post-phase) the intervention. At the pre-phase, students attended the first test and assignment. Then at the post-phase, the second test and assignment enrolled. Both experimental and control group students are given in pre-phase using the same learning materials from the same teacher out of class, as shown in Figure 1. This learning material is usually uploaded to the online system. Students watched videos and accessed the material prior to class to gain knowledge before enrolling in the tests. Then, the experimental groups go to the peer-coaching flipping classroom method. Each of the groups would be assigned one outstanding student as a tutor to coach their

small experimental group. On the other hand, in the control group, there were no tutors assigned, and students could communicate and interact freely and ask each other for help with the topics. After all the topics, they are given post-phase tests and assignments to examine their knowledge of all the topics.

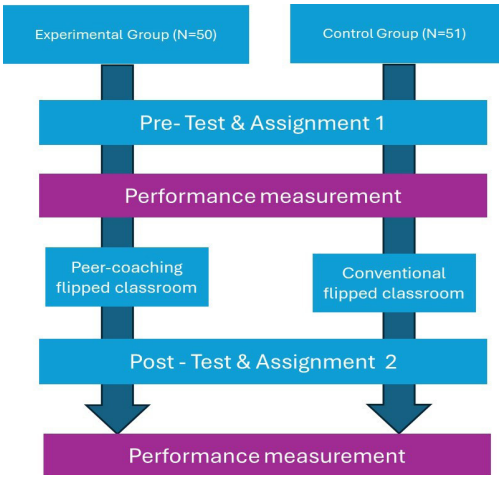


Figure 1 Study design comparing the impact of peer-coaching versus conventional flipped classroom methods on student performance, with assessments conducted before and after the interventions

Data Analysis

The students' scores collected through tests and assignments conducted in the pre- and post-study phases of the planned study. As a first step in the data analysis, the descriptive statistics of scores for the experimental and control groups (mean and standard deviation) are calculated. The scores are then divided into five categories (0-10%, 10%-20%, 20%-30%, 30%-40%, 40%-50%) to illustrate the difference between the students' scores in the pre- and post-study phases. To evaluate the difference between the groups based on a statistical significance test and to determine the effect size of the differences, both the T-test and Cohen's d are calculated.

T-test

To determine whether there are statistically significant differences between two groups in the pre- and post-study phases, the independent samples t-test was performed a t-test was applied to test the study hypotheses. In this study, the null hypothesis (H_0): There is no significant difference in performance between the experimental and control groups. The alternative hypothesis (H_1): There is a significant difference in performance between the experimental and control groups. Based on the probability value (p-value) of less than 0.05 was considered statistically significant. If the p-value is less than 0.05 in this study, the null hypothesis is rejected and it is concluded that the effect of peer coaching in the flipped classroom is statistically significant.

Effect Size (Cohen's d)

The independent samples t-test was performed to determine whether there were statistically significant differences between the two groups in the pre- and post-study phases. A T-test was applied to test the study hypotheses. In this study, the null hypothesis (H0): There is no significant difference in performance between the experimental and control groups. While the alternative hypothesis (H1): There is a significant difference in performance between the experimental and control groups. Based on the probability value (p-value) of less than 0.05 was considered statistically significant. If the p-value is less than 0.05, the null hypothesis is rejected, and it is concluded that the effect of peer coaching in the flipped classroom is statistically significant.

$$Cohen's\ d = \frac{\mu_1 - \mu_2}{\sigma_{pooled}}$$

In this study, μ1 and μ2 are the means of the two groups, experimental and control groups, respectively. The σ pooled is the pooled standard deviation of the two groups, calculated

using the following formula, where the n_1 and n_2 sample size for each group, and σ^1 and σ^2 are the standard deviation for experimental and control groups, respectively,

$$a_{pooled} = \sqrt{\frac{(n_1 - 1)\sigma_1^2 + (n_{12} - 1)\sigma_2^2}{n_1 + n_2 - 2}}$$

The interpretation of Cohen's d values usually follows three thresholds for assessing the size of the effect observed in the differences between experimental and control groups,

a. Small effect size = 0.2
b. Medium effect size = 0.5
c. Large effect size = 0.8

Results and Discussions

In this study, the performance of students from the experimental and control groups were compared. The setting of the experimental group was deployed with the peer coaching flipped classroom method, while the setting of the control group was deployed with the conventional flipped classroom method. Their performance in the study was tested based on test and assignment scores administered in the pre- and post-study phases. Data was then analysed using t-tests to determine the statistical significance of the differences and effect sizes were generated to appreciate the practical significance.

Experimental Group

Figures 2 and Figure 3 illustrate the distribution of student scores within the specified categories for tests and assignments before and after applying the peer coaching flipped classroom method. Based on the percentage of students, it is noted that the number of students who scored between 40-50% increased from the pre and post-study phases from 30% to 40%. The number of students who scored between 30-40% dropped from 25% to 20% in the post-test. This indicates a general improvement in performance as more students move up into higher grade categories.

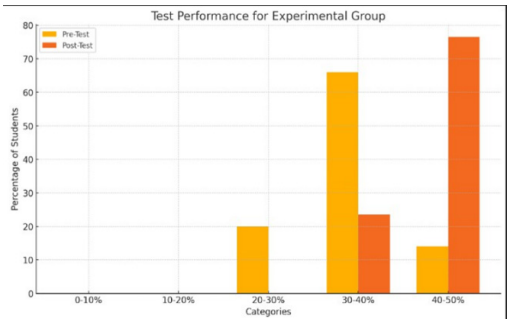


Figure 2 Test performance for experiment group

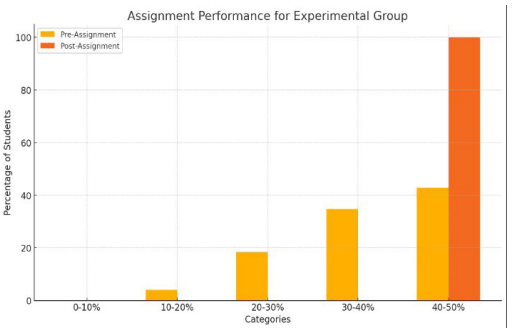


Figure 3 Assignment performance for the control group

Student performance on assignments shows that the number of students scoring between 40-50% increased significantly from 40% on the pre-assignment to 70% on the post-assignment. The number of students who scored between 30-40% fell from 30% to 20%. This decline shows that the student's performance has improved overall because of the intervention.

Table 1 shows the mean, SD, p-value and effect size for the experimental group's scores at different measurement phases. The table shows differences in the mean scores between the students' performances. The difference in

Table 1 Statistical analysis results for the experimental group

Measure	Mean	SD	p-value	Effect Size (Cohen's d)
Pre-Test	64.68	8.90	0.0651	-0.37
Post-Test	71.52	11.58	< 0.0001	2.04
Pre-Assignment	73.44	17.49	0.4593	0.15
Post-Assignment	74.83	6.42	< 0.0001	2.61

Table 2 Statistal analysis results for control group

Measure	Mean	SD	p-value	Effect Size (Cohen's d)
Pre-Test	68.23	9.29	0.0651	-0.37
Post-Test	69.01	10.86	0.2135	0.25
Pre-Assignment	70.86	16.24	0.4683	0.11
Post-Assignment	76.73	7.64	0.2316	-0.24

grades between the two phases of the study based on the p-value and Cohen's d The significant improvements in post-test and assignment scores underscore the effectiveness of the peer coaching method in the flipped classroom.

Control Group

The bar chart in Figures 4 and 5 illustrates student scores' distribution in the pre-test and post-test phases and post-assignment and post-assessment for the control group. Based on the percentage of students in the pre-test phase, approximately 70% scored in the 30-40% category. In the post-test phase, this percentage dropped slightly to about 65%, indicating a slight shift in student performance from the 30-40% to 40-50% category.

On the other hand, student performance on the assignments shows that in the pre-test phase, about 35% of the students were in the 30-40% category. In the post-assignment phase, this percentage increased to about 45%. This indicates that more students scored in the middle after the intervention. The percentage of students scoring in the '30-40%' category increased, indicating that more students moved into the middle category after the intervention, while the percentage of students scoring in the '40-50%' category remained stable with a slight increase, indicating consistent higher achievement.

These observations suggest that the students' performance in the control group improved overall after applying the conventional flipped classroom method.

The statistical analysis in Table 2 shows no significant difference in student performance between the pre- and post-test phases. The mean of the post-test for the control group is 69.01, with a standard deviation of 10.86. The p-value of 0.2135 shows that the difference in the post-test scores is not statistically significant. The effect size of 0.25 indicates a small effect, suggesting a slight but insignificant improvement in performance.

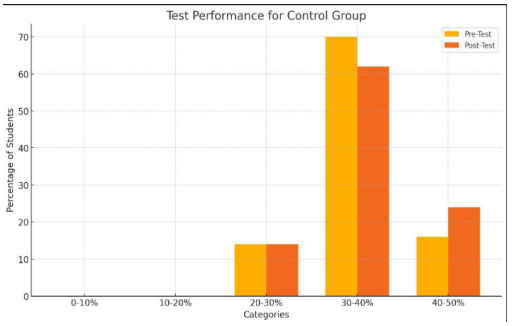


Figure 4 Test performance for control group

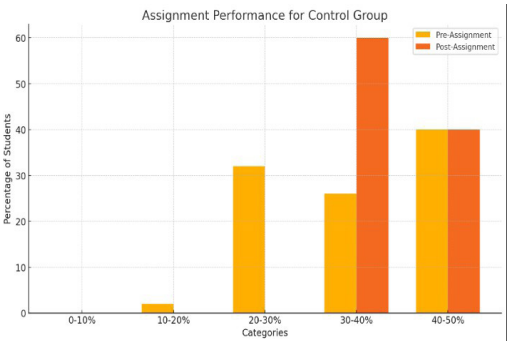


Figure 5 Assignment performance for control group

Conclusion

This empirical study was performed to understand how students observed their experience studying through peer-coaching flipping classroom method in the Introduction to AI course. In this study, the findings show the significance of peer-coaching flipped classrooms in enhancing academic achievement and scores in the selected course. However, one limitation of the current study is the relatively small sample size, which may limit the generalizability of the results. Future studies could involve a larger cohort from multiple institutions to validate the findings across different educational settings. Besides, it would be beneficial to conduct studies comparing multiple teaching methods in parallel, including traditional, flipped, and hybrid models, to understand better each approach's advantages and limitations in promoting student engagement and learning.

Acknowledgement

The authors are thankful for the facility and support from the Department of Electrical and Electronic Engineering, Universiti Teknologi PETRONAS, to use the EEB 4013: Introduction to Artificial Intelligence course data.

References

Rohl A., Reddy, S. & ShannonG.J. (2013). The Flipped Classroom: An Opportunity to Engage Millennial Students through Active Learning Strategies. *Journal of Family and Consumer Sciences*, *105*(2), 44-49.

Dennis, C.-L. (2003). Peer Support Within a Health Care Context: A Concept Analysis. *International Journal of Nursing Studies*, *40*(3), 321-332.

Foertsch, J., Moses, G., Strikwerda, J., & Litzkow, M. (2002). Reversing the Lecture/ Homework Paradigm Using eTEACH® Web-based Streaming Video Software. *Journal of Engineering Education*, *91*(3), 267-274.

Garrett, J., & Honeycutt, B. (eds.) (2013). *The Flipped Approach to a Learner-Centered Class*. Madison: Magna Publications White Paper.

Gribble, N., Ladyshewsky, R. K., & Parsons, R. (2019). The Impact of Clinical Placements on the Emotional Intelligence of Occupational Therapy, Physiotherapy, Speech Pathology, and Business Students: a Longitudinal Study. *BMC Medical Education*, *19*(1), 90.

Hagen, M. S., & Tani K. Bialek, S. L. (2017). The Nature of Peer Coaching: Definitions, Goals, Processes and Outcomes. *European Journal of Training and Development*, *41*(6), 540-558.

Hao, Y. (2016). Exploring Undergraduates' Perspectives and Flipped Learning Readiness in Their Flipped Classrooms. *Computers in Human Behavior*, *5*, 82-92.

Hohensee, C., & E.Lewis, W. (2018). Building Bridges: A Cross-Disciplinary Peer-Coaching Self-Study. *Studying Teacher Education*, *15*(2), 98-117.

Jin, M. G. (2023). Artificial Intelligence, Education, and Entrepreneurship. *The Journal of Finance*, *79*(1), 63-667.

Kwan, P., Memon, T. D., Hashmi, S. S., Rhode, F., & Kadel, R. (2022). An Empirical Study of Students' Perception of and Key Factors Affecting Overall Satisfaction in an Intensive Block Mode and Flipped Classroom. *Education Sciences*, *12*(8), 19-20.

Li, Z. L. (2022). Using the Flipped Classroom to Promote Learner Engagement for the Sustainable Development of Language Skills: A Mixed-Methods Study. *Sustainability*, *14*(10), 5983.

Liu, L., Ripley, D., & Lee, A. (2016). Flipped Learning and Influential Factors: Case Analysis. *Journal of Educational Technology Development and Exchange*, *9*(2), 85-103.

Magana, A. C., Magana, E. C., & Guillen-Gamez, F. D. (2022). Analysis of Prospective Teachers' Perceptions of the Flipped Classroom Methodology. *Societies, 12*(4), 1-15.

Niesen, P. L., Bean, N. W., & Larsen, R. A. (2018). The Impact of a Flipped Classroom Model of Learning on a Large Undergraduate Statistic Class. *Statistics Education Research Journal*, *17*(1), 121-140.

Parker, P., Kram, K. E., & Hall, D. T. (2014). Peer Coaching: An Untapped Resources for Development. *Organisational Dynamics*, *43*(2), 122-129.

Peterson, D. J. (2015). The Flipped Classroom Improves Student Achievement and Course Satisfaction in a Statistics Course: A Quasi-Experimental Study. *Teaching of Psychology*, *43*(1), 10-15.

Riley, B. A. (2018). Using the Flipped Classroom With Simulation-Based Medical Education to Engage Millennial Osteopathic Medical Students. *Journal of Osteopathic* Medicine, *118*(10), 673-678.

Saira, Ajmal, F., & Hafeez, M. (2021). Critical Review on Flipped Classroom Model versus Traditional Lecture Method. *International Journal of Education and Practice*, *9*(1), 128-140.

Shinaberger, L. (2017). Components of a Flipped Classroom Influencing Student Success in an Undergraduate Business Statistics Course. *Journal of Statistics Education*, *25*(3), 122-130.

Stohr, C., Demaziere, C., & Adawi, T. (2020). The Polarising Effect of the Online Flipped Classroom. Computer & Education, *147*, 103789.

Tian, N., & Tsai, S.-B. (2021). An Empirical Study on Interactive Flipped Classroom Model Based on Digital Micro-Video Course by Big Data Analysis and Models. *Mathematical Problems in Engineering,* 1-11.

Utami, U., Ghufron, A., & Setiawati, F. A. (2024). A Systematic Literature Review of Flipped Classroom: Is It Effective On Student Learning In Elementary School? *Pegem Journal of Education and Instruction*, *14*(1), 244-251.

Xu, L.-J., Yu, S.-Q., Chen, S.-D., & Ji, S.-P. (2019). Effects of the Flipped Classroom Model on Student Performance and Interaction with a Peer-Coach Strategy. *Education Studies*, *47*(3), 1-20.

Zhang, S., Liu, Q., & Wang, Q. (2016). A Study of Peer Coaching in Teachers' Online Professional Learning Communities. *Universal Access in the Information Society*, *16*, 337-347.

Exploring The Motivational Impact of Stage Sketches on Student-Centred Learning

Nurul Izni Kairi
Centre for Foundation Studies,Universiti Teknologi PETRONAS, Malaysia
*nurulizni.kairi@utp.edu.my

Introduction

The problems in learning chemistry at various levels are a common issue in all chemistry instructors face. The abstract nature of many challenging chemistry concepts often hinders the teaching and learning of chemistry in the foundational level classroom as the students frequently struggle to grasp them. Students often find it difficult to identify key concepts and understand their relationships, leading to a superficial grasp of chemistry confined to theoretical knowledge. This limitation hampers their ability to apply these concepts in real-life situations, preventing them from developing the scientific thinking necessary to analyse and solve everyday problems (Dewi et. al., 2022).

Conventional approaches in chemistry education that focus on repetitive learning and heavy curricula often intensify this problem. These approaches tend to focus on knowledge acquisition rather than fostering a deep understanding of critical thinking skills and problem-solving abilities. As a result, students may achieve good grades but cannot apply their knowledge to real-world contexts. Problem-based learning (PBL) involves students working on scenarios, cases, questions, or problems. This approach usually precedes conventional classroom settings, promoting self-directed learning and facilitating the scaffolding process, allowing students to self-discover the topics. Role play and case study projects are two examples of student-centred active learning practices that are beneficial in helping students replicate abstract concepts and make them more relatable to them (Tang, 2023; Anand, 2021). This approach will foster students' originality, creativity, and ability to make wise decisions, raise students' cognitive thinking abilities and produce well-rounded graduates.

An assignment-based competition was introduced to address these challenges, emphasising role-play as a stage sketch presentation approach to enhance student engagement and understanding of General Chemistry and Physical Chemistry topics. The stages are divided into two parts. The first stage requires all students to complete an assignment based on case studies, where they analyse and solve chemistry-related problems, and the submission is in the form of a recorded sketch presentation. In the second stage, selected finalists present their solutions through role-play, simulating real-world scenarios where chemistry concepts are applied in a staged sketch.

This method, underpinned by research on the effectiveness of role-play and case study assignments in chemistry education (McSharry & Jones, 2000; Dewi et al., 2022), aims to bridge the gap between theoretical knowledge and practical application. By actively engaging students in learning through real-life simulations, this approach promotes a deeper, more applicable understanding of chemistry.

It equips students with the critical thinking skills necessary to think scientifically and solve complex problems, thus preparing them for both academic and professional success.

Related Work/Literature Review

In a study by Costa et al. (2023), PBL was adopted for several chemistry courses, comparing its effectiveness between face-to-face and online formats as set by COVID-19 restrictions. The results showed that although the face-to-face format of PBL is generally preferred, the online format also favourably affects student learning and satisfaction when properly designed using online platforms. Students rated online PBL positively compared to traditional online teaching. The collaborative nature of PBL, with problem-solving in groups, only improves motivation among students for the support of effective learning. Basically, PBL has an interactive and group approach that best serves both on-campus and online environments.

A separate study by Anand, 2021 reflects on the application of case studies in science learning, explaining how such methods strengthen problem-solving skills and critical thinking. A literature review of case studies reveals that they bridge the gap between theoretical learning and practice.

The review by Tang (2023) discusses the benefits of active learning strategies, such as role-play and case studies, in chemistry education. It underscores how these methods can make abstract concepts more tangible and relatable, thereby improving student engagement and comprehension. This was further discussed by the work of McSharry and Jones (2000) who finds that role-play and simulations in chemistry can significantly enhance the understanding of complex flagship concepts because students can now relate to the material in a more applied and interactive approach.

Given these findings, using stage sketches combined with case studies might be a productive approach to enhancing motivation among students learning chemistry. PBL and case studies/role-plays' interactive and collaborative attributes, a much deeper understanding of chemistry are more likely to develop. This approach not only further refines skills in problem-solving and critical thinking but makes learning more meaningful and fun.

Research Methodology

Teaching and Learning Theories

This study explores the motivational impact of stage sketches within student-centred learning, aiming at constructivist and experiential learning theories. Constructivism suggests that learners build knowledge through active engagement and personal experiences rather than passively receiving information. Stage sketches offer a tangible and related learning experience that positively impacts students' learning journey. This study also examines how role-play and active participation enhance students' learning experience, motivation, critical thinking, and problem-solving skills, aligning with the connection to the syllabi and promoting self-directed learning.

Sample of Students

This study focuses on the FBC0015/FCC0015 – Chemistry I course and FBC0025-Chemistry II course in the May 2024 semester. The number of students involved is summarised in Figure 1.

Instruments

We used two primary research instruments to evaluate the effectiveness of the role-play (sketch presentation) approach in enhancing student motivation: a student survey and a judge feedback form. Questions about their performance levels were taken to establish the effectiveness of the role-play approach in elevating student motivation. Also,

demographic information and feedback regarding experience in learning — difficulties and advice on improvement—were obtained.

The judge feedback instrument addressed the quality of the study. They judged the application of chemistry ideas, the nature of problems solved, and students' enthusiasm. They commented generally on strengths and weaknesses and overall impressions of how well student learning was supported using the role-play method versus the conventional.

Identifying trends and gathering insights from data collected helped us determine if the role-play approach effectively motivated students to learn chemistry. The following is a flow chart of the stages of the study that has been carried out (Figure 1).

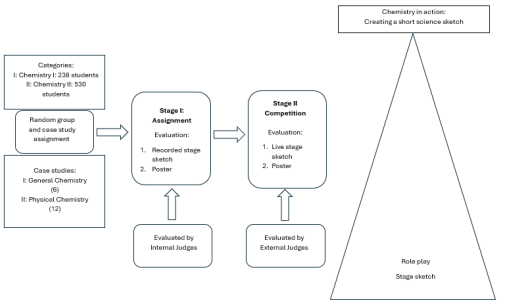


Figure 1 Stages adopted in the study

Result and Discussions

In the first stage of our study, students submitted role-play sketch presentations in video format that illustrated various chemistry concepts. Figure 2 depicts the sample submissions extracted from the video submissions. In the second stage of our study, students presented live on stage, as depicted in Figure 3. Evidence of students' creativity and imagination can be seen in their submissions, including the poster submissions, as shown in Figure 4. The poster submission is aimed to summarise the work submitted for their staged sketch, where evidence of imagination and creativity is introduced here.



Figure 2 Assignment submissions extracted from the video





Figure 3 Live stage sketches during the final competition



Figure 4 Poster submissions

The survey, which captured responses from various students enrolled in Chemistry I and Chemistry II, shows that the majority of students found the sketch presentation format to be beneficial in enhancing their understanding of chemistry concepts. From the data displayed in Figure 5, more than 80% of the students agree with the survey questions related to the learning outcomes attainment, learning experience, motivation, relevancy, and adaptability of the method. In terms of the evaluation of the learning process, the evaluation reveals that the stage sketch presentation experience was useful within the framework of the course. Most students felt that the assignment made them learn by applying their theoretical knowledge in a practical but extremely creative manner. This would link to the experiential learning approach, whereby students develop a deeper understanding and retention of complex subjects like chemistry through active participation in assignments such as stage sketches (Taskin-Can, 2013).



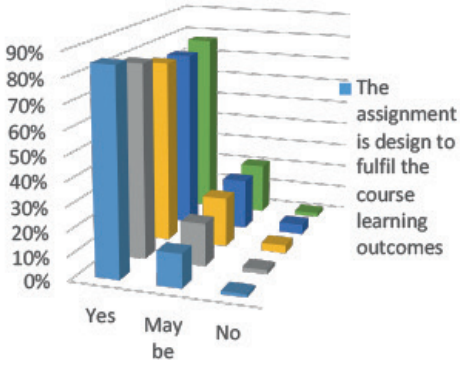


Figure 5 Students' feedback on their learning experiences

Similarly, students also reacted positively to the process of assessment. The data indicated that the structure of the assignments allowed autonomy to be encouraged, which is vital in developing independent learners. Apart from this, assessments were said to have motivated the students. Based on this finding, it can be seen that the creative and performative nature of the sketch presentation, together with the rubric-based evaluations that cover the area of technical and non-technical, succeeded in enhancing the students' motivation and increasing commitment to the task of learning,

supported by the data outlined in Figure 6. This result shows that the stage sketch significantly improved students' soft skills, such as self-discipline-independence in learning, self-confidence, and interactions. Students were grouped into a random team that enabled them to pull out the capabilities and strengths of the members. This has also enhanced their interaction despite the challenge of managing the time and commitment among the team members, as supported by the inclination of the data towards teamwork as the most enhanced skill.

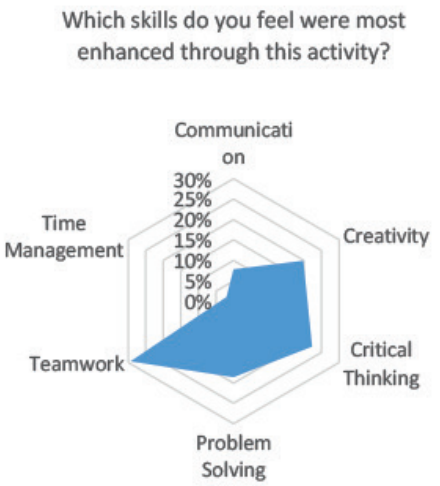


Figure 6 Spider diagram on the most enhanced skills

In terms of the level of satisfaction gauged from the activity, the results highlight that students felt more motivated and committed to their assignments due to the innovative presentation format. This increase in motivation can be attributed to the engaging nature of stage sketches, which likely made the learning experience more enjoyable and memorable. The positive feedback from peers and instructors during the presentations further reinforced this sense of commitment, as supported by the data in Figure 7.

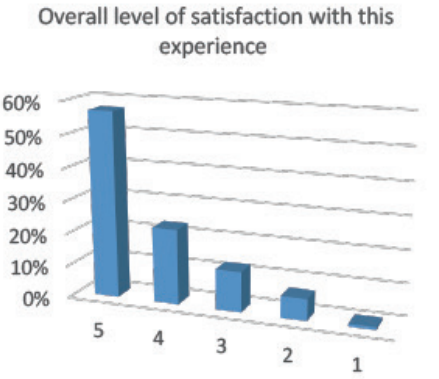


Figure 7 Satisfaction level with the overall experience

The effectiveness of this teaching strategy can be attributed to its alignment with problem-based and experiential learning methodologies. Allowing students to express their understanding through stage sketches creatively encourages them to think critically and collaboratively, enhancing their cognitive and affective skills. The rubric-based evaluation ensures that students are assessed fairly and comprehensively, considering various aspects of their performance, including content knowledge, creativity, and presentation skills.

The data also underscores the importance of integrating innovative assessment methods that resonate with students' interests and learning styles. The positive impact on student motivation and commitment indicates that such creative approaches can play a crucial role in overcoming the challenges of low engagement and weak foundational knowledge in chemistry. As suggested by the evaluation from the judges, as shown in Figure 8, Over 70% of judges agreed on the performance's enjoyment, script quality, and the suitability of costumes and props. Literature would support that engaging performances enhance learning with a well-crafted script to guide the narrative, appropriate costumes that add authenticity, and effective props furthering the storytelling.

These combined create a cohesive and impactful experience (Bernardi & Pazinato, 2022; Wahyuni, 2020), consistent with the positive feedback received from the evaluation conducted by the judges. More than 70% agreed that the framework is good and suggest to continue the use of a similar framework in the future, Figure 9.

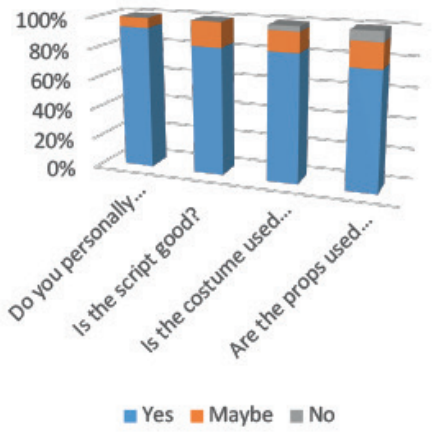


Figure 8 Feedback from the judges

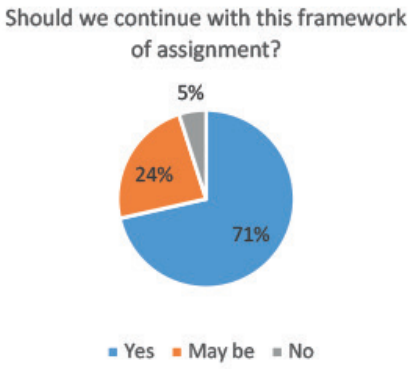


Figure 9 Suitability of the framework to be adopted in the future

Table 1 illustrates the sample of case studies assigned to the students where they can greatly apply all of the knowledge they have gained throughout this activity, which resonates with the application in our daily lives. Based on the categories, six different case studies have been created for the Chemistry I course and 12 different case studies for the Chemistry II course to introduce various applications of the knowledge to the students.

Stage sketches, or role-play presentations, profoundly influence long-term learning outcomes by increasing engagement, enhancing retention, and promoting a stronger grasp of complex concepts. These activities transform learning into an enjoyable experience, reducing the monotony often associated with conventional lectures. The enjoyment students feel boosts their motivation, essential for sustaining interest in a subject over time.

Apart from that, these sketches encourage students to translate complex concepts into relatable scenarios, deepening understanding and thus fostering better critical thinking. By incorporating the knowledge practically, students not only strengthen their concepts but also develop essential soft skills like confidence, communication and teamwork. This motivational and skill-building impact forms a strong platform for a more interactive and long-lasting learning experience.

Conclusion

Feedback from students and judges revealed that the stage sketches significantly improved engagement, motivation, and understanding. Students found the format made abstract concepts more accessible and appreciated the collaborative nature. Judges noted the enhanced application of theoretical knowledge and increased motivation. The students supported the findings. The role-play method effectively bridged theory and practice.

In conclusion, the case study assignments presented as stage sketch presentations have proven to be an effective pedagogical tool in chemistry education. The results from this study support the continued use and further exploration of similar creative and experiential learning approaches in other areas of science education.

Table 1 Snapshot of the case studies assigned to the students

CS#	Chapter	Case Study	Scenario	Task
CS1	2: Stoichiometry	Baking Bread: A Stoichiometry Case Study	In a small bakery called "Golden Crust," located in a bustling neighbourhood, the baker, Mia, faces a dilemma. The bakery has received a large order for bread rolls from a nearby café for an upcoming event. However, Mia realises that she doesn't have enough flour to fulfil the order. To complicate matters, she needs to ensure that the bread rolls turn out perfectly fluffy and delicious, just like her customers expect. Mia knows that she needs to calculate the precise amount of ingredients needed to produce the required number of bread rolls without compromising on quality.	Mia decides to apply stoichiometry principles to solve her problem. She needs to calculate the exact quantities of flour, water, yeast, salt, and other ingredients required to make the desired number of bread rolls. Additionally, she must consider the chemical reactions involved in the bread-making process, such as the fermentation of yeast and the conversion of sugars to carbon dioxide gas, which gives the bread its airy texture. Mia's challenge is not only to produce enough bread rolls to fulfil the order but also to ensure that each roll meets the bakery's high standards of taste and texture. To complete the task, Mia must: 1. Determine the stoichiometric ratios for the chemical reactions involved in bread-making. 2. Calculate the amount of flour, water, yeast, salt, and other ingredients needed based on the desired number of bread rolls. 3. Consider factors such as rising time, temperature, and humidity that may affect the bread-making process. 4. Adjust the recipe as necessary to account for any variations in ingredient quality or equipment performance. 5. Monitor the baking process closely to ensure that the bread rolls are baked to perfection.
CS2	2: Stoichiometry	Acid Spill at Crystal Lake	Crystal Lake, a beloved natural haven, faces a crisis when a tanker accident spills acid into its waters. This catastrophe devastates the environment, harms wildlife, and threatens the health of nearby residents. The community's cherished lake now stands polluted and in urgent need of help.	As pre-university students studying chemistry, your task is to apply the principles of acid-base neutralisation and stoichiometry to address the aftermath of the spill at Crystal Lake. Here's what you need to do, 1. Understanding Acid-Base Chemistry: a. Explore the concepts of acids and bases, including their properties and reactions. b. Investigate how acid spills can disrupt the pH balance of natural water systems like Crystal Lake. 2. Assessing the Spill's Impact: a. Analyse the extent of the acid spill and its effect on Crystal Lake's pH levels. b. Consider how changes in pH can harm aquatic life and water quality. 3. Applying Stoichiometry: a. Use stoichiometric calculations to determine the amount of base needed to neutralise the acid in Crystal Lake. b. Consider factors such as the volume of the lake and the concentration of the acid spill.

cont.... **Table 1**

CS#	Chapter	Case Study	Scenario	Task
CS3	2: Stoichiometry	pH Rescue: A Stoichiometry Case Study for Farming	In the village of Greenvale, the local farmer, Mr. Patel, faces a problem with his soil. Over the years, excessive use of fertilisers has made parts of his fields too acidic. This acidity is harming the crops, and Mr. Patel worries about his livelihood. He needs a solution to restore the soil's pH balance and keep his crops healthy.	Mr. Patel decides to use stoichiometry to solve his soil problem. His task is to figure out how much lime (a base) he needs to add to neutralise the acidity in his soil. He also needs to consider how to apply the lime evenly across his fields. To complete the task, Mr. Patel must, 1. Find out the right amount of lime needed to neutralise the acid in the soil. 2. Calculate how much lime he needs based on the area of the field and the current soil pH. 3. Think about how to spread the lime evenly so that all parts of the field benefit. 4. Keep an eye on the soil's pH over time to make sure the treatment is working.
CS4	2: Stoichiometry	Perfecting the Recipe: A Stoichiometry Case Study in Cooking	In the bustling kitchen of "Chef's Delight," a popular restaurant known for its exquisite culinary creations, Chef Mia is preparing for a special event. She plans to showcase her signature dish, a mouthwatering lemon meringue pie, which has earned rave reviews from customers. However, Chef Mia encounters an unexpected challenge: she realises that the acidity of the lemon filling needs to be balanced to achieve the perfect flavour and texture. Without the right balance, the pie could turn out too tart or overly sweet, disappointing her discerning diners.	Chef Mia decides to apply stoichiometry principles to adjust the acidity of the lemon filling and achieve the ideal balance of flavours in her pie. Her task is to calculate the precise amount of a base, such as baking soda or cream of tartar, needed to neutralise the acidity of the lemon juice without altering the pie's taste or consistency. Additionally, she must ensure that the chemical reaction between the acid and base does not affect the pie's texture or appearance. To complete the task, Chef Mia must, 1. Determine the stoichiometric ratio for the neutralisation reaction between the acidic components in the lemon juice (e.g., citric acid) and the chosen base. 2. Calculate the amount of base required to neutralise the acidity of the lemon filling based on the recipe's proportions and the desired level of tartness. 3. Consider factors such as the volume of lemon juice, the pH of the filling, and the sensitivity of other ingredients to changes in acidity. 4. Adjust the recipe accordingly to incorporate the calculated amount of base while maintaining the integrity of the pie's flavour and texture. 5. Taste-test the lemon filling throughout the process to ensure that the desired balance of flavours is achieved before assembling and baking the pie.

cont.... **Table 1**

CS#	Chapter	Case Study	Scenario	Task
CS5	3: Quantum Theory and The Electronic Structure of Atoms	Atoms: Unveiling the Hidden Forces Shaping Everyday Life	Imagine a group of high school students who are passionate about science and are participating in a science fair competition. They want to explore the concept of atomic structure and its relevance in daily life. Their task is to create a case study that demonstrates how atomic structure influences a specific aspect of everyday life.	To complete the task: 1. Choose a specific application or product in daily life where atomic structure plays a crucial role. This could be anything from the functioning of a household item to the development of a technological innovation. 2. Research the atomic structure of the materials involved in the chosen application or product. Identify the elements, their atomic numbers, and electron configurations, and explain how these properties contribute to the product's functionality. 3. Analyse and explain the relationship between the atomic structure and the observed properties or behaviours of the chosen application or product. How do the arrangement of atoms, types of bonds, or electron configurations influence its function or performance? 4. Present your findings in a comprehensive case study format, including an introduction to atomic structure, a description of the chosen application or product, an analysis of its atomic structure, and a conclusion discussing the significance of atomic structure in daily life. 5. Prepare a visual aid, such as a poster or presentation slides, to effectively communicate your case study to a general audience. Use diagrams, illustrations, and examples to enhance understanding.
CS6	3: Quantum Theory and The Electronic Structure of Atoms	The Application of Atomic Structure in Daily Life	Emma, a high school chemistry teacher, is preparing a series of lessons on atomic structure and its practical applications in daily life. To make the topic engaging and relevant for her students, she decided to incorporate a case study that shows how understanding the atomic structure can solve real-world problems. She chooses to focus on the practical use of atomic knowledge in the development of modern batteries, specifically lithium-ion batteries, which are widely used in smartphones, laptops, and electric vehicles.	Emma's task is to design a comprehensive case study that not only explains the basic concepts of atomic structure but also demonstrates how this knowledge is applied in the design and functioning of lithium-ion batteries. The case study will include background information, real-world applications, and a hands-on activity for students to deepen their understanding.

cont.... **Table 1**

S#	Chapter	Case Study	Scenario	Task
CS1	1: Properties of Solution	Freezing Point Depression in Road Salting	A local government is responsible for maintaining road safety during winter months when temperatures drop below freezing. They use salt (sodium chloride) to de-ice roads and prevent accidents. However, they want to understand the science behind this process to optimize their salt usage.	Your group is hired to investigate the phenomenon of freezing point depression and its application in road salting. You must provide a theoretical explanation to determine how different concentrations of salt affect the freezing point of water and calculate the effectiveness of salt in preventing ice formation on roads.
CS2	1: Properties of Solution	Osmosis in Plant Cells	A farmer is experiencing wilting and reduced crop yields in his fields, despite regular watering. He suspects that there may be issues with water uptake in the plant cells.	Your group is hired to investigate the role of osmosis in plant cells and its implications for agriculture. You must conduct experiments to demonstrate osmotic processes in plant cells, including the effects of hypertonic, hypotonic, and isotonic solutions on cell turgor pressure and water uptake. Additionally, propose strategies for optimizing water management in agriculture to improve crop health and productivity.
CS3	1: Properties of Solution	Boiling Point Elevation in Food Preservation	A food processing company is looking for ways to extend the shelf life of their products without relying on chemical preservatives. They are interested in utilizing the principle of boiling point elevation to increase the effectiveness of thermal processing methods.	Your group is hired to research and develop a food preservation method based on boiling point elevation. You must investigate how the addition of solutes, such as salt or sugar, affects the boiling point of water and the microbial stability of food products. Additionally, propose guidelines for implementing this preservation method in food processing facilities to ensure product safety and quality.
CS4	1: Properties of Solution	Vapour Pressure Lowering in Cooking	A chef is experimenting with different cooking techniques to improve the flavor and texture of his dishes. He notices that some recipes call for adding salt to boiling water before cooking pasta or vegetables, while others do not. He wonders how the addition of salt affects the cooking process and the final outcome of the dish.	Your group is hired to investigate the phenomenon of vapor pressure lowering and its application in cooking. You must explore how the addition of solutes, such as salt, affects the boiling point and vapor pressure of water, and how these changes influence the cooking process and food quality. Additionally, propose guidelines for using vapor pressure lowering techniques to enhance the flavor, texture, and nutritional value of various dishes.To complete the task: 1. Develop guidelines for incorporating vapor pressure lowering techniques into cooking recipes. 2. Provide recommendations for the optimal salt concentration and cooking time for different types of foods. 3. Explore creative ways to enhance the flavor and texture of dishes using vapor pressure lowering, such as brining meats or marinating vegetables. 4. Discuss the potential health implications of consuming foods cooked with salt and propose alternatives for reducing sodium intake while still achieving desired culinary outcomes.

cont.... **Table 1**

CS5	2: Chemical Kinetics	Autoignition in Combustion Engines **Top of Form**	You are an automotive engineer working for a leading car manufacturer tasked with optimizing the performance and reducing emissions of a new internal combustion engine design. The company is committed to sustainability and seeks to minimize environmental impact while maintaining high-performance standards. Your team has been assigned to investigate the kinetics behind the autoignition process in the engine to understand how factors such as temperature, pressure, and fuel composition affect ignition delay times. By gaining insights into ignition kinetics, you aim to optimize engine design and operation for improved efficiency and reduced emissions.	To complete the task: 1. Conduct a comprehensive literature review on the autoignition process in internal combustion engines, focusing on relevant research articles, journals, and textbooks. Gather information on key concepts, theories, and experimental methods related to ignition kinetics, including factors influencing ignition delay times such as temperature, pressure, and fuel composition. 2. Design and perform experimental studies to investigate the effects of temperature, pressure, and fuel composition on ignition delay times. Develop experimental setups and protocols for conducting ignition delay measurements under controlled conditions representative of engine operating environments. 3. Analyze experimental data to identify trends and correlations between ignition delay times and varying parameters such as temperature, pressure, and fuel composition. Use statistical methods and data visualization techniques to interpret results and draw meaningful conclusions about the kinetics of the autoignition process. 4. Apply insights from your studies to optimize engine design and operation for improved performance and reduced emissions. Propose engineering solutions or modifications aimed at controlling ignition kinetics to enhance combustion efficiency, minimize fuel consumption, and reduce pollutant emissions.
CS6	2: Chemical Kinetics	Analyzing Environmental Impact Post-Meteor Strike: A Chemical Kinetics Approach	A meteor has crashed into a remote area, causing significant environmental upheaval. The impact site is now a focal point for scientific investigation to understand the aftermath of the collision. Researchers aim to unravel the chemical changes triggered by the meteor strike and devise strategies to mitigate environmental damage.	Using principles of chemical kinetics, analyze the reactions occurring in the aftermath of the meteor strike. Quantify reaction rates, assess environmental impact, and propose remediation strategies.

cont.... **Table 1**

CS7	3: Thermochemistry and Chemical Thermodynamics	Energy Efficiency in a High School Cafeteria **Top of Form**	Greenfield High School is committed to reducing its carbon footprint and promoting sustainability. The school cafeteria is a central hub where students gather for meals throughout the day. However, the cafeteria's energy consumption has been a concern, with high electricity bills and inefficient equipment contributing to environmental impact.	As part of a school project on energy efficiency, students are tasked with evaluating the cafeteria's energy usage and proposing solutions to improve efficiency. Their analysis should include: 1. Identifying energy-consuming appliances and systems in the cafeteria, such as refrigerators, ovens, lighting, and ventilation. 2. Assessing the efficiency of these appliances and systems and determining areas of potential improvement. 3. Researching energy-saving practices and technologies that could be implemented in the cafeteria. 4. Developing a plan to reduce energy waste and promote sustainability within the cafeteria, considering factors like cost-effectiveness and feasibility. 5. Presenting their findings and recommendations to school administrators and cafeteria staff.
CS8	3: Thermochemistry and Chemical Thermodynamics	The Application of Thermochemistry in Daily Life	Sarah is a high school chemistry teacher who has noticed that her students struggle to see the practical applications of the concepts they learn in class. To make thermochemistry more relatable, she decides to create a project that connects these principles to a real-world situation. Sarah designs a case study around the concept of energy transfer in cooking, specifically focusing on the efficiency of different cooking methods. She plans to use this project to help her students understand how thermochemical principles apply to everyday activities and to enhance their problem-solving skills.	Sarah asks her students to investigate the energy efficiency and heat transfer properties of various cooking methods: boiling, steaming, and microwaving. Each student group will select a common food item (e.g., vegetables or rice) and compare how each method affects cooking time, energy consumption, and the nutritional value of the food.
CS9	4: Electrochemistry	Electrochemistry in Dentistry (Teeth Whitening)	You are a high school student interning at a dental clinic during your summer break. One day, the dentist you are assisting explains to you the importance of electrochemistry in dentistry. She mentions that electrochemistry plays a crucial role in various dental procedures, such as teeth whitening and dental implants. She assigns you a task to understand and explain the electrochemical processes involved in these procedures.	To complete the task, you must research on teeth whitening. Your task is to research and explain how electrochemistry is used in teeth whitening procedures. You need to understand the role of hydrogen peroxide and its breakdown into reactive oxygen species (ROS) during the whitening process. Additionally, explain how the application of an electric current enhances the whitening effect. Prepare a brief presentation to explain these concepts to the dentist.

cont.... **Table 1**

CS10	4: Electrochemistry	Electrochemistry in Dentistry (Dental Implants)	You are a high school student interning at a dental clinic during your summer break. One day, the dentist you are assisting explains to you the importance of electrochemistry in dentistry. She mentions that electrochemistry plays a crucial role in various dental procedures, such as teeth whitening and dental implants. She assigns you a task to understand and explain the electrochemical processes involved in these procedures.	To complete the task, you must research on dental implants. Your task is to explore the electrochemical processes involved in dental implants. Research how titanium implants interact with the surrounding tissues in the mouth through a process called osseointegration. Understand how the surface properties of titanium implants are modified using electrochemical techniques to promote osseointegration. Prepare a summary report detailing the electrochemical principles behind this process to simplify difficult concept.
CS11	4: Electrochemistry	The Electrochemical Magic of Batteries 1. Top of Form	You are a student in a pre-university chemistry class, and your teacher has assigned you a project to explore the application of electrochemistry in daily life. You decide to investigate the role of batteries in powering everyday devices.	Your task is to research and create a presentation that explains the electrochemical principles behind batteries and their significance in daily life. You will also demonstrate how different types of batteries work and compare their advantages and disadvantages. Provide real-life examples or case studies that illustrate the importance of batteries in specific scenarios. For instance, you could discuss how advancements in battery technology have enabled the widespread adoption of electric vehicles and renewable energy storage systems.
CS12	4: Electrochemistry	Electroplating Jewelry at a High School Workshop **Top of Form**	Greenfield High School offers a jewelry-making workshop where students learn various techniques to create their pieces. The workshop has recently introduced electroplating as a method to add a layer of metal onto jewelry pieces, enhancing their appearance and durability. However, students are encountering challenges with the electroplating process, including inconsistent plating results and equipment issues.	As part of a class project on electrochemistry, students are tasked with improving the electroplating process in the workshop. Their analysis should include: 1. Understanding the principles of electroplating and how it relates to the transfer of electrons during chemical reactions. 2. Identifying the key components of the electroplating setup, including the anode, cathode, electrolyte solution, and power source. 3. Investigating factors that affect the quality of electroplating, such as the type of metal used, current density, and immersion time. 4. Troubleshooting common problems encountered during electroplating, such as uneven plating, blistering, or poor adhesion. 5. Proposing solutions to address these challenges and improve the overall electroplating process in the workshop.

Acknowledgement

The author would like to thank the Centre for Foundation Studies and Centre for Student Development, UTP for the encouragement, support, and financial assistance to run the study.

References

Costa, A.M., Escaja, N., Fité, C., González M., Madurga, S. Fuguet, E. (2023). Problem-based learning in graduate and undergraduate chemistry courses: face-to-face and online experiences. *Journal of Chemical Education. 100*(2), 597-606. Doi: 10.1021/acs.jchemmed.2c.00741

Anand, N. (2021). Impact of informal learning environments on STEM education: Views of elementary students and their parents. *School Science and Mathematics. 121*(6), 369-377. Doi: https://doi.org/10.1111/ssm.12490

Anand, S. A. A. (2021). Flipped pedagogy: Strategies and technologies in chemistry education. *Materials Today: Proceedings. 47*(91), 240-246. Doi: 10.1016/j.matpr.2021.04.133

Bernardi, F. M., & Pazinato, M. (2022). The case study method in chemistry teaching: A systematic review. *Journal of Chemical Education*. *99*(3), 1211-1219. Doi: 10.1021/acs.jchemed.1c00733

Taskin-Can, B., (2013). The Effects of using creative drama in science education on students' achievements and scientific process skills. *Elementary Education Online*, 12(1), 120-131.

Tang K.H.D. (2023). Student-centered approach in teaching and learning: What does it really mean? *Acta Pedagogia Asiana, 2*(2), 72-83. Doi: 10.53623/apga.v2i2.218

Dewi, C.A., Habiddin, H., Dasna, I.W., & Rahayu, S. (2022). Case-Based Learning (CBL) in Chemistry learning: A systematic review. *Jurnal Penelitian Pendidikan IPA*., *8*(4), 2219-2230. Doi: 10.29303/jppipa.v8i4.1971

McSharry, G. & Jones, S. (2000). Role-play in science teaching and learning. *School Science Review*. *82*(298), 73-82.

Wahyuni, S, Rahmatan H., Mahidin & Sulastri (2020). The effect of role-playing model on students'critical thinking skills and interest in learning chemical bonds concept. *Journal of Physics: Conf. Series*. *1460*, 012088. Doi:10.1088/1742-6596/1460/1/012088

Enhancing Student Engagement and Learning Outcomes through Game-Based Learning

Teh Hee Min
Department of Civil & Environmental Engineering, Universiti Teknologi PETRONAS, Malaysia.
*heemin.teh@utp.edu.my

Introduction

In recent years, Game-Based Learning (GBL) has emerged as a powerful educational tool that leverages the engaging and interactive nature of games to enhance learning outcomes. As education evolves in response to technological advancements and changing student needs, GBL has gained traction for its potential to transform traditional teaching methods into more dynamic and student-centred experiences. Research has shown that GBL can significantly increase student engagement, motivation, and understanding, making it a valuable strategy in various educational settings (Gee, 2003; Prensky, 2007).

Engagement is a critical factor in effective learning, and GBL excels in capturing students' attention by incorporating elements of play and competition. These elements not only make learning more enjoyable but also foster deeper involvement in the learning process (Shaffer, 2006). Studies have demonstrated that students who participate in GBL activities are more likely to remain focused and retain information better than those who engage in traditional learning methods (Annetta et al., 2009). Furthermore, GBL promotes active learning, where students are not passive recipients of information but active participants who apply concepts in practical, game-based scenarios (Barab et al., 2009). In addition to enhancing engagement, GBL also supports the development of critical thinking, problem-solving, and collaboration skills. The interactive nature of games encourages students to experiment, take risks, and learn from their mistakes in a safe environment (Plass et al., 2015). Moreover, multiplayer and collaborative games promote teamwork and communication, which are essential skills in both academic and professional contexts (Kim et al., 2009). As education increasingly emphasises the importance of 21st-century skills, GBL offers a promising approach to preparing students for future challenges.

Sustainable Concrete Technology is a core course within the Civil Engineering program at Universiti Teknologi PETRONAS (UTP). This course emphasises the nature, performance, and physical and mechanical properties of concrete materials, including cement and aggregates. It introduces students to ordinary cement concrete mix design to address the needs of the construction industry while also exploring alternative cementitious materials and technologies that enhance the service life and sustainability of concrete. The learning outcomes for this course are detailed in Table 1.

The Sustainable Concrete Technology course challenges students due to its extensive factual content, making it dense and often perceived as dull. The heavy emphasis on memorising numerous details about concrete materials, mix design, and related technologies can be

Table 1 Course learning outcomes for Sustainable Concrete Technology

Course Learning Outcomes	
1	Explain the classification, types and characterisation of concrete constituent materials.
2	Develop ordinary cement concrete mixture designs based on the construction project requirements.
3	Analyse other cement replacement materials and technologies to enhance the service life performance of concrete.

overwhelming, leading to a lack of engagement. Many students struggle with traditional reading-intensive courses, finding them uninteresting and challenging to connect practically. This has resulted in a growing dissatisfaction with the course, underscoring the need for more interactive and engaging teaching approaches to enhance student interest and comprehension.

To address the challenge of students finding the Sustainable Concrete Technology course heavy and dull due to its extensive factual content, incorporating GBL can offer an innovative solution. The GBL is anticipated to transform traditional reading-intensive courses into interactive, engaging experiences by integrating game elements that make learning more enjoyable and dynamic. The intention of this research is to enhance student engagement and knowledge retention in the Sustainable Concrete Technology course by integrating Game-Based Learning (GBL) strategies, making the learning process more interactive, enjoyable, and effective. Based on student perceptions, this paper aims to evaluate its effectiveness across several key domains, including engagement, understanding, motivation, collaboration, skills development, and overall satisfaction.

Methodology

To enhance the learning experience, a Game-Based Learning (GBL) approach was implemented for the Sustainable Concrete Technology course during the May 2024 semester. The course had 12 students enrolled. Two types of GBL activities were conducted for the May 2024 Semester: two cycles of the Kahoot game and the 'Read, Answer & Run (RAR)' game. For the RAR game-based activity, a spacious room was set up before the game (Figures 1 and 2).



Figure 1 Set-up outside the game room



Figure 2 Set-up in the game room

The procedures of the RAR game-based activity were as follows,

1. Each student enters the game venue one at a time.
2. The student is given two minutes to read the assigned material (Figure 3).
3. When the bell rings, the student quickly moves to a designated location to answer three questions related to the reading material using an online platform within two minutes (Figure 4).
4. This process is repeated until each student answers all questions.

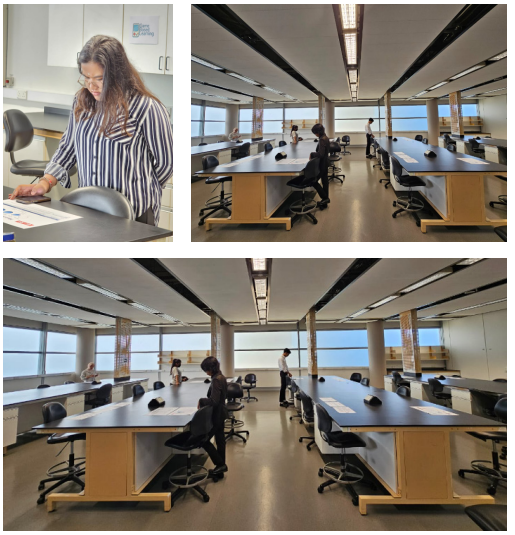


Figure 3 Self-reading of the given materials for two minutes



Figure 4 Answering the given questions via forms

After the game, students were asked to complete a questionnaire to assess their perceptions of the learning experience with GBL. The purpose of the questionnaire was to capture a comprehensive view of their experiences with GBL. Students were instructed to indicate their level of agreement with each statement using the following response options: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. 11 students responded to this questionnaire survey. Rewards were given to the top 3 scorers upon completion of the learning activity (Figure 5).

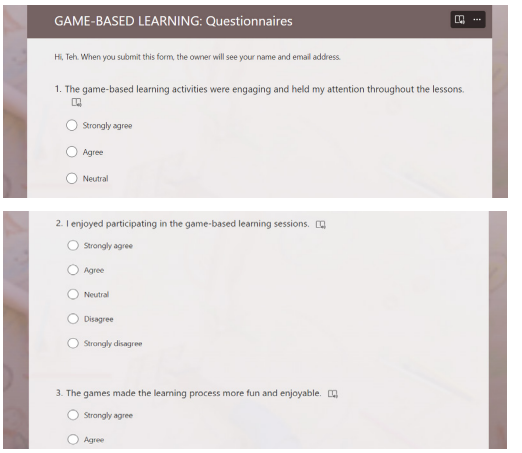


Figure 5 Online questionnaire via forms



Figure 6 Rewarding the winners with some goodies

Results and Discussions

The outcomes of the questionnaire survey are reported across six domains, i.e., engagement (Figure 7), understanding (Figure 8), motivation (Figure 9), collaboration (Figure 10), skills development (Figure 11), and overall satisfaction (Figure 12).

Engagement: Students reported high levels of engagement, with 100% strongly agreeing that games made them feel more involved in the lessons. A significant majority (91-100%) found the games fun, enjoyable, and attention-holding, indicating that GBL effectively captures and maintains student interest.

Understanding: GBL was also found to enhance understanding, with strong agreement (73-82%) on the games' ability to clarify complex concepts, provide immediate feedback, and help retain information. The integration of games with course objectives was well-received, contributing to a more relatable and effective learning experience.

Motivation: Motivation levels were similarly high, with 73-82% of students strongly preferring GBL over traditional methods, finding it more motivating and confidence-boosting. Competitive elements and rewards in the games were cited as key motivators, further increasing interest and participation in the subject matter.



Figure 7 Sampled questions that address the student engagement domain

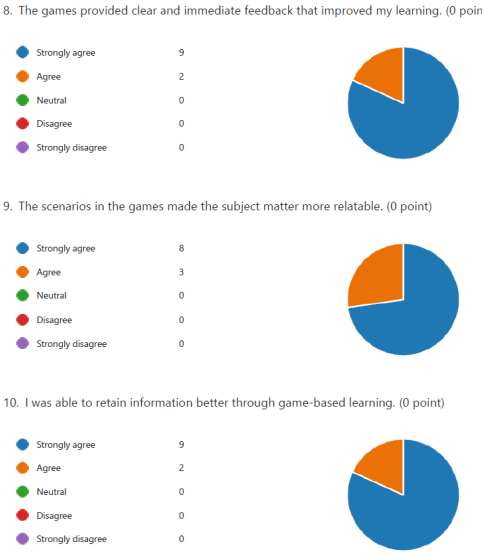
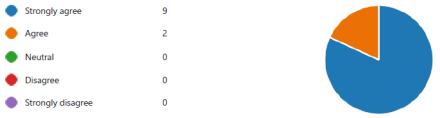
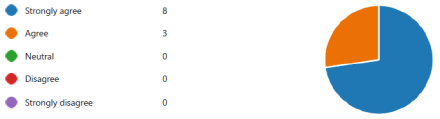


Figure 8 Sampled questions that address the student's understanding domain

15. The competitive elements of the games encouraged me to try harder. (0 point)



16. The rewards and achievements in the games motivated me to continue learning. (0 point)



17. Game-based learning increased my overall interest in the subject. (0 point)

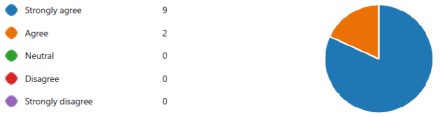
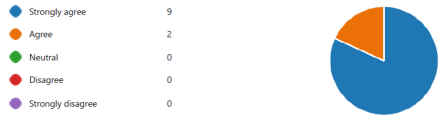
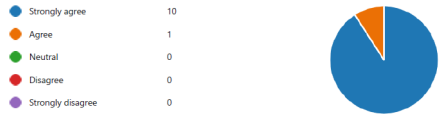


Figure 9 Sampled questions that address the student motivation domain

24. The games encouraged me to share ideas and strategies with others. (0 point)



25. Working in teams during game-based learning helped me learn from my peers. (0 point)



26. The social interaction in the games made learning more enjoyable. (0 point)

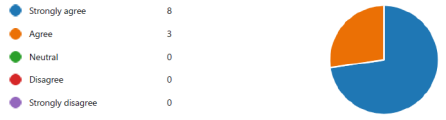
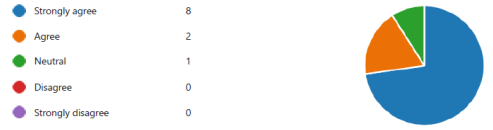


Figure 10 Sampled questions that address the student collaboration domain

27. Game-based learning helped me improve my problem-solving skills. (0 point)



28. The games enhanced my critical thinking abilities. (0 point)

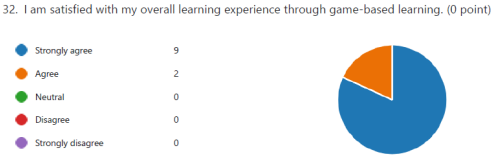


29. I developed better decision-making skills through game-based learning. (0 point)

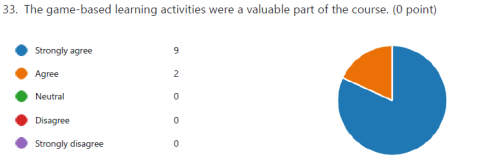


Figure 11 Sampled questions that address the student skill development domain

32. I am satisfied with my overall learning experience through game-based learning. (0 point)



33. The game-based learning activities were a valuable part of the course. (0 point)



34. I would recommend game-based learning to other students. (0 point)

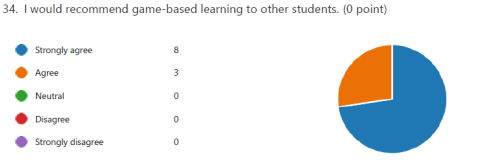


Figure 12 Sampled questions that address the overall student satisfaction domain

Collaboration: Collaboration during GBL was another standout, with 73-91% of students strongly agreeing that games promoted teamwork, communication, and peer learning. The social interaction within games made learning more enjoyable and fostered a collaborative learning environment.

Skills Development: Students recognised GBL as a valuable tool for developing essential skills. A majority (73%) strongly agreed that it improved problem-solving, critical thinking, decision-making, and time management skills. Additionally, 73% of students strongly agreed that GBL helped them become more resilient when facing challenges.

Overall Satisfaction: Satisfaction with GBL was high, with 82-91% of students expressing strong satisfaction with their overall learning experience. They considered GBL a valuable part of the course and were enthusiastic about its positive impact on their academic performance. Most students (91%) strongly supported including more GBL activities in future courses.

Conclusion

In conclusion, the analysis demonstrates that Game-Based Learning (GBL) is highly effective in enhancing student engagement, understanding, motivation, collaboration, and skills development. This approach makes the learning process more interactive and alleviates the monotony of memorisation, making complex material more accessible and appealing to students. As a result, GBL can significantly enhance student engagement and satisfaction, addressing the core issues of the course.

Acknowledgements

The author would like to thank the participating students – Sustainable Concrete Technology May 2024 Semester for their support rendered for the game-based learning activities implemented in the course.

References

Annetta, L. A., Minogue, J., Holmes, S. Y., & Cheng, M. T. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education*, *53*(1), 74-85.

Barab, S. A., Gresalfi, M., & Ingram-Goble, A. (2010). Transformational play: Using games to position person, content, and context. *Educational Researcher*, *39*(7), 525-536.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy.* Palgrave Macmillan.

Kim, S., Song, K., Lockee, B., & Burton, J. (2009*). What is Game-Based Learning?*. In *Handbook of Research on Effective Electronic Gaming in Education* (pp. 1-20). IGI Global.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015) Foundations of Game-Based Learning. *Educational Psychologist*, *50*(4), 258-283.

Prensky, M. (2007). *Digital game-based learning.* New York: Paragon House.

Shaffer, D. W. (2006). *How computer games help children learn.* London: Palgrave Macmillan.

Safeload: Enhancing HSE Training Through Immersive Metaverse Experiences

Ariff Imran Rostam*, Khairul Shafee Kalid, Gehad Mohamed Ahmad Naji, Savita Sugathan, Ahmad Adib Safariel Sahadan
Universiti Teknologi PETRONAS, Malaysia
*ariffimran15@gmail.com

Introduction

Health, Safety, and Environmental (HSE) courses are vital components of university curricula, as they equip students with the knowledge and skills necessary to navigate and manage risks in various industries. The importance of HSE education lies in its ability to foster a culture of safety and environmental responsibility, which is critical in today's world. By understanding the principles of HSE, students are better prepared to identify potential risks, implement preventive measures, and contribute to creating safer workplaces and sustainable practices. However, the current approach to teaching HSE is mostly lecture-based (Fam et al., 2012). Students often struggle to grasp the real-world implications of safety protocols (Kongsvik et al., 2016) because they lack experience dealing with actual incidents. Virtual reality (VR) is being incorporated into HSE education to tackle this challenge, offering students immersive simulations that mimic real-life situations. This approach allows students to experience and respond to potential hazards in a controlled environment, enhancing their understanding and retention of critical safety concepts.

The metaverse holds even more significant potential for revolutionising HSE education (Tang et al., 2024). By creating fully interactive and interconnected virtual environments, the metaverse can allow students to engage in complex, multi-user simulations that mirror real-world situations more closely than ever (Lee et al., 2021). In these virtual spaces, students can collaborate, explore, and respond to evolving safety challenges, all within a dynamic, immersive setting that promotes deeper learning and engagement (Lin et al., 2022). The metaverse thus represents the next frontier in HSE education.

This study aims to develop a VR application based on the metaverse concept called *SafeLoad: A Virtual Guide to Suspended Load Safety*. This application aims to show a digital world that demonstrates one of PETRONAS Zeto Rules: *Do Not Position Yourself Under a Suspended Load*.

Methodology

The development of SafeLoad is based on the Rapid Application Development (RAD) technique, as shown in Figure 1.

The research methodology involves several key phases, starting with the Planning stage, where the research problem is defined, a timeline is planned, and a literature review is compiled. This will be followed by the Conceptual Design and Development phase, which focuses on defining learning objectives and designing a VR application for HSE. The requirements are compiled through literature and sessions

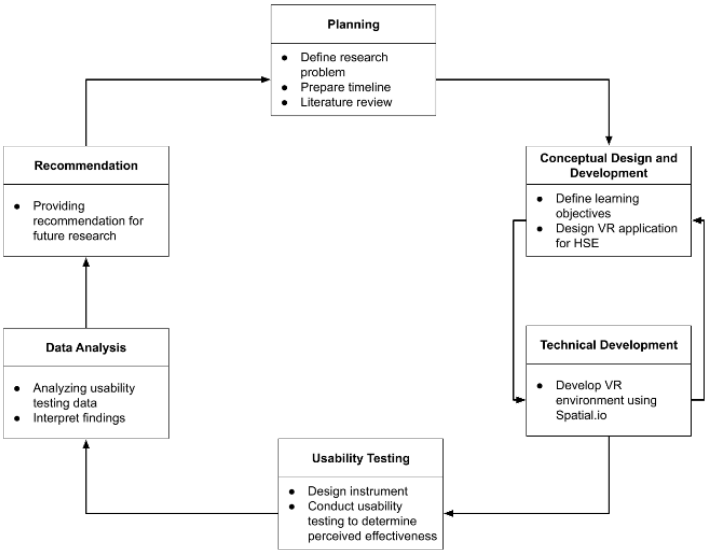


Figure 1 Research phases

with the Universiti Teknologi PETRONAS (UTP) HSE Department. The VR environment was developed using the Spatial.io platform during the Technical Development phase. The 3D models were developed using Unity or obtained from external sources. The design and construction of the digital environment underwent several iterations based on the feedback from the UTP HSE department. Usability testing is then conducted, where an instrument is designed, and usability testing is performed to determine the VR environment's perceived effectiveness. The prototype is evaluated heuristically by users to identify any usability issues and provide recommendations for improvement. The data gathered from usability testing is analysed in the Data Analysis phase, with findings interpreted to assess the application's performance. Finally, the Recommendation phase suggests future research to enhance the VR application for HSE training.

Design and Development

SafeLoad consists of six interconnected scenes. As depicted in Figure 2, the user's avatar moves sequentially through these scenes, beginning with the first and ending with the sixth.

To fully complete the experience, the avatar must visit three designated checkpoints in scenes three, four, and five. At each checkpoint, the user learns about forklift safety, warehouse dangers, and associated risks with suspended

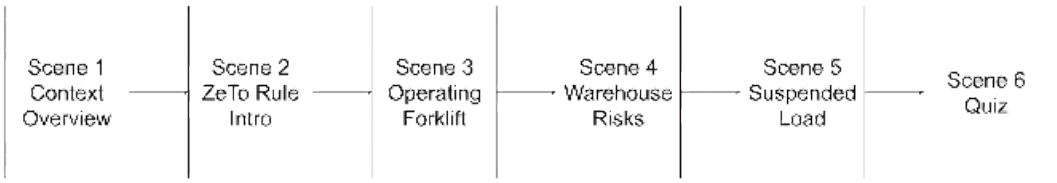


Figure 2 SafeLoad scene structure

loads. Once all checkpoints have complete visited, the user must take a quiz to demonstrate their understanding of the material.



Figure 3 Scene 1: Context overview

Figure 2 shows Scene 1: Context Overview. This scene provides the context of the learning and the virtual world itself. From this scene, the avatar will begin its tour of the virtual world after this scene.



Figure 3 Scene 2: Suspended load introduction

Figure 3 shows Scene 2: Zeto Rule Introduction. This scene begins at the main entrance of the warehouse. The warehouse consists of a number of high shelves. The numbers on the shelves indicate the avatar's . These numbered s acts as a guide the direction of the avatar.

Usability Testing

A group of 10 participants agreed to assess SafeLoad's effectiveness and usability. These participants are fourth-year engineering students who have taken Health and Safety Environment subjects and have been exposed to HSE in companies during their internship. The participants were asked to explore SafeLoad and evaluate the application's effectiveness and usability. The participants answer a series of questions through Microsoft Form. The results were mostly positive. From the context of effectiveness, 80% responded that SafeLoad is very effective in simulating and clarifying the do's and don'ts in the warehouse with high suspension loads. The findings strongly suggest that the metaverse effectively conveyed best practices in health and safety environments. In terms of overall usability, participants feel that SafeLoad has provided an exceptional user experience. The findings suggest that the metaverse interface was well-designed and easy to use, contributing to a positive and efficient learning experience.

Conclusion

The study's findings demonstrate the substantial potential of metaverse technology to enhance HSE training. The immersive and interactive simulation enables users to engage with safety protocols in a controlled environment, fostering improved information retention and practical application. However, this approach has challenges, including the initial development costs and the requisite technological infrastructure. The results underscore the need for further exploration of the scalability of metaverse-based training modules across various industries. Future research should further investigate integrating more advanced components, such as artificial intelligence, to personalise the training experience.

References

Fam, I. M., Nikoomaram, H., & Soltanian, A. (2012). Comparative Analysis of Creative and Classic Training Methods in HSE Participation Improvement. *Journal of Loss Prevention in the Process Industries*, 25(2), 250-253

Kongsvik, T., Gjøsund, G., & Vikland, K. M. (2016). HSE culture in the petroleum industry: Lost in translation? *Safety Science, 81*, 81–89. Doi:0.1016/j.ssci.2015.04.019

Lee, L., Braud, T., Zhou, P., Wang, L., Xu, D., Lin, Z., Kumar, A., Bermejo, C., & Hui, P. (2021). All One Needs to Know about Metaverse: A Complete Survey on Technological Singularity, Virtual Ecosystem, and Research Agenda. arXiv.org. https://arxiv.org/abs/2110.05352

Lin, H., Wan, S., Gan, W., Chen, J., & Chao, H. C. (2022). Metaverse in education: Vision, opportunities, and challenges. In *2022 IEEE International Conference on Big Data (Big Data)* (pp. 2857-2866). IEEE.

Tang, Y., Liang, H., & Zhan, J. (2024). The Application of Metaverse in Occupational Health. *Frontiers in Public Health, 12*.

Next-Gen Learning: A Novel Integration Of AR, AI, and Spatial Computing in Student-Centric Education

Daniel Tonye Oyefidein[*1], Precious Ada Josiah[2], Shamsuddeen Adamu[1]
[1]Computer and Information Science Universiti Teknologi PETRONAS, Malaysia
[2]Center for Corrosion Engineering, Universiti Teknologi PETRONAS, Malaysia
[*]daniel_24001664@utp.edu.my

Introduction

Advancements in Augmented Reality (AR), Artificial Intelligence (AI) and spatial computing are revolutionising educational practices, providing innovative solutions to enhance learning experiences (Akçayır & Akçayır, 2017; Kesim & Ozarslan, 2012; Thomas et al., 2014; Yuen et al., 2011). Traditional educational models often struggle to meet diverse learner needs and maintain engagement, as Bower et al. (2014) and Radu (2014) noted. This paper presents a novel learning system integrating AR, AI, and spatial computing into a cohesive, student-centered platform. Central to this system are AR glasses equipped with AI capabilities that enable real-time monitoring of student engagement and personalised learning pathways. By analysing biometric data, such as facial expressions and body language, the system provides educators with immediate insights into students' focus and emotional states, facilitating timely interventions (Alcañiz et al., 2010; Ardiny & Khanmirza, 2018)

Additionally, facial recognition technology allows access to individualised learning profiles, informing adaptive learning paths tailored to each student's unique needs. This data-driven approach represents a significant advancement over traditional methods, promising a more engaging and effective learning environment (Avila-Garzon et al., 2021). This innovative system aims to foster a more adaptive and inclusive educational experience in the digital era by utilising these technologies.

Related Works

Bower et al. (2014) reviewed AR applications in education, highlighting the potential to enhance student engagement and interactive learning. Radu (2014) emphasised AR's effectiveness in promoting experiential learning, showing improved information retention compared to traditional methods. (Azuma, 1997) laid the foundational framework for AR technologies, outlining essential characteristics relevant to educational contexts. (Zhang et al., 2022) explored AR integration in K-12 education, revealing significant enhancements in student motivation and interest in subjects like science. Dunleavy and Dede (2014) noted challenges in implementing AR, emphasising the need to address accessibility and teacher training. Kerr and Lawson (2020) examined AR's role in design education, illustrating how AR tools facilitate creative processes. Wu et al. (2013) conducted a meta-analysis, concluding that AR enhances learning outcomes and promotes critical thinking (Akçayır et al., 2016). These findings corroborated these findings, indicating higher student engagement and satisfaction.

This body of literature underscores AR's transformative potential in education while highlighting the need for ongoing research to address implementation challenges.

Methodology

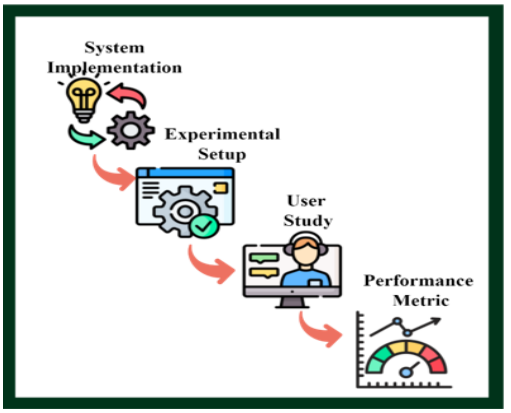


Figure 1 Flow chart of the methodology

Table 1 System implementation

Component	Description
AR Glasses Hardware	Use of customisable AR glasses like Microsoft HoloLens 2 or Magic Leap 2 with built-in cameras, spatial sensors, and gesture recognition capabilities.
Biometric Sensors Integration	Biometric sensors monitor facial expressions and physiological signals for real-time mood and engagement.
Open-Source AI Frameworks	AI frameworks like OpenFace (facial recognition) and DeepFace (emotion detection) for tracking student engagement.
Machine Learning Models	Use of TensorFlow or PyTorch for personalised content delivery based on student profiles and learning performance.
Prototype Testing	Simulation tests for facial recognition accuracy, emotion detection, gesture responsiveness, and system stability.

Table 2 Experimental setup

Aspect	Description
Classroom Testing	Real-world classroom setup involving diverse students.
Data Collection	Biometric feedback, facial recognition, and AI monitoring of student attention, academic performance, and retention.
Outcome Analysis	Evaluate system impact on attention, comprehension, and overall learning outcomes.

Table 3 User study

Aspect	Description
Participants	Both students and instructors are involved in qualitative feedback.
Focus Areas	Usability, effectiveness, adaptation to individual learning needs, and comfort with gesture controls.
Ethical Considerations	Ensuring data privacy, anonymising facial recognition data, and compliance with GDPR.

Table 4 Performance metric

Metric	Description
Engagement Improvements	Measured through AI-driven mood tracking and increased attention spans.
Personalisation Efficiency	Assessed by how well AI adapts learning content to individual needs based on real-time data.
Learning Outcomes	Evaluated through improvements in academic performance, retention rates, and overall comprehension.

Discussion

This proposal anticipates creating a sophisticated AR learning system incorporating AI capabilities, including mood tracking, facial recognition, and gesture-based control. The system is expected to leverage customisable AR hardware, such as the Microsoft HoloLens 2, to accurately recognise students and dynamically tailor educational content according to their emotional and cognitive states in real time (Gheisari et al.,2023).

The AI-driven mood-tracking component is engineered to analyse biometric data to identify cognitive fatigue or disengagement signs. This functionality will enable timely, personalised interventions to enhance student engagement (Cabero-Almenara et al., 2019). Additionally, the integration of gesture-controlled interactions will facilitate seamless, hands-free navigation, thereby cultivating an immersive and distraction-free learning environment (Starner et al., 1997).

We anticipate that these innovations will lead to a 20-30% increase in student engagement and improved learning outcomes, mainly by delivering adaptive content and contextually relevant real-world examples. These features aim to create a more interactive, personalised, and responsive educational experience that caters to each student's unique needs.

Conclusion

This paper introduces an innovative AR glasses system that effectively integrates AR, AI, and spatial computing to revolutionise the conventional educational experience. The system employs AI-driven mood tracking, facial recognition, and gesture-controlled interactions to establish a highly personalised learning environment. By dynamically adjusting to each student's emotional and cognitive states, the system delivers customised content, enhances engagement, and provides real-time feedback. This advancement addresses significant shortcomings in current educational technologies by offering a holistic solution that improves student engagement and learning outcomes.

Future Perspective

In the future, this system will extend well beyond immediate classroom applications. When successfully implemented, this technology has the potential to transform educational systems worldwide, promoting adaptive, inclusive, and student-centred learning across various contexts. As AR, AI, and spatial computing technologies continue to gain traction, these systems could empower educators to concentrate on personalised learning pathways, thereby addressing disparities in educational equity and fostering more engaging and effective learning environments.

References

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, *20*, 1-11.

Akçayır, M., Akçayır, G., Pektaş, H. M., & Ocak, M. A. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior*, *57*, 334-342.

Alcañiz, M., Contero, M., Pérez-López, D. C., & Ortega, M. (2010). Augmented reality technology for education. In Soomro, S. (ed.) *New Achievements in Technology, Education and Development*. London: IntechOpen.

Ardiny, H., & Khanmirza, E. (2018). The role of AR and VR technologies in education developments: opportunities and challenges. 2018 6th RSI International conference on robotics and mechatronics (IcRoM), 22-25 Oct, IEEE.

Avila-Garzon, C., Bacca-Acosta, J., Duarte, J., & Betancourt, J. (2021). Augmented reality in education: An Overview of Twenty-Five Years of Research. *Contemporary Educational Technology*, *13*(3). Doi:10.30935/cedtech/10865

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments,* MIT Press Direct, 6(4),

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented reality in education: Cases, places and potentials. *Educational Media International*, *51*(1), 1-15.

Cabero-Almenara, J., Barroso-Osuna, J., Llorente-Cejudo, C., & Fernández Martínez, M. d. M. (2019). Educational uses of augmented reality (AR): Experiences in Educational Science. *Sustainability*, *11*(18), 4990.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In Spector, J. M, Merill, M. D., Elen, J. & Bishop (eds.), *Handbook of Research on Educational Communications and Technology*, 735-745.

Gheisari, M., Becerik-Gerber, B., & Dossick, C. S. (2023). Emerging learning technologies for the future of work and education in engineering. *Adv. Eng. Informatics*, *56*, 101775.

Kerr, J., & Lawson, G. (2020). Augmented reality in design education: Landscape architecture studies as AR experience. *International Journal of Art & Design Education*, *39*(1), 6-21.

Kesim, M., & Ozarslan, Y. (2012). Augmented reality in education: current technologies and the potential for education. *Procedia-social and Behavioral Sciences*, *47*, 297-302.

Radu, I. (2014). Augmented reality in education: a meta-review and cross-media analysis. *Personal and Ubiquitous Computing*, *18*, 1533-1543.

Starner, T., Mann, S., Rhodes, B., Levine, J., Healey, J., Kirsch, D., Picard, R. W., & Pentland, A. (1997). Augmented reality through wearable computing. *Presence: Teleoperators & Virtual Environments*, *6*(4), 386-398.

Thomas, B. H., Marner, M., Smith, R. T., Elsayed, N. A. M., Von Itzstein, S., Klein, K., Adcock, M., Eades, P., Irlitti, A., & Zucco, J. (2014). *Spatial augmented reality: A tool for 3D data visualisation.* 2014 IEEE VIS international workshop on 3DVis (3DVis),

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., & Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, *62*, 41-49.

Yuen, S. C.-Y., Yaoyuneyong, G., & Johnson, E. (2011). Augmented reality: An overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange (JETDE), 4*(1), 11.

Zhang, J., Li, G., Huang, Q., Feng, Q., & Luo, H. (2022). Augmented reality in K–12 education: A systematic review and meta-analysis of the literature from 2000 to 2020. *Sustainability*, *14*(15), 9725.

Enhancing Student Engagement and Performance in Engineering Mathematics Course: A Blended and Cooperative Learning Approach

Mohana Sundaram Muthuvalu*, Majid Khan Majahar Ali, Jumat Sulaiman
Universiti Teknologi PETRONAS, Malaysia
mohana.muthuvalu@utp.edu.my

Introduction

The fast-paced evolution of educational technologies and pedagogical methods has revealed the need for more dynamic and interactive teaching strategies in science, technology, engineering, and mathematics (STEM) education. While effective in transmitting core knowledge, traditional lecture-based approaches often lead to passive learning, where students may not engage deeply with the material. In subjects such as engineering mathematics, where students are required to apply abstract theoretical concepts such as calculus and ordinary differential equations (ODEs) to solve complex engineering problems, this lack of active engagement can result in surface-level understanding (Freeman et al., 2014).

Research indicates that students often struggle to bridge the gap between theoretical knowledge and practical applications in mathematics, which is a critical component of engineering education. Many students report difficulties understanding calculus-based concepts and applying these principles to solve real-world problems. These challenges affect academic performance and diminish students' confidence in solving engineering problems (Charalambides et al., 2023).

This study investigates integrating blended learning and cooperative learning strategy in the Engineering Mathematics II (EM II) course at Universiti Teknologi PETRONAS (UTP). By combining asynchronous pre-recorded video lectures with in-class collaborative activities, such as Think-Pair-Share, the study aims to enhance student engagement and understanding of calculus and differential equations in solving engineering problems. This teaching approach also seeks to develop critical communication and teamwork skills essential for success in engineering disciplines.

Literature Review

The demand for innovative teaching strategies in higher education has spurred a growing body of research exploring the effectiveness of active learning methods in improving student engagement and academic performance. Active learning encourages students to take responsibility for their education by actively participating in discussions, problem-solving, and group activities instead of passively receiving information from an instructor (Freeman et al., 2014). Studies have shown that active learning significantly enhances student understanding and retention, particularly in subjects that require complex problem-solving, such as mathematics (Ballen et al., 2017).

Blended learning is an active learning strategy that has gained widespread recognition recently. Blended learning combines traditional face-to-face instruction with online components, allowing students to engage with course materials

at their own pace. The asynchronous nature of online learning will enable students to revisit complex topics and better prepare for interactive classroom activities (O'Flaherty & Phillips, 2015). According to Platonova et al. (2022), students who participate in blended learning environments show improved satisfaction and higher academic performance than those in traditional lecture-based settings. The flexibility of blended learning is particularly beneficial in mathematics courses, where students often need additional time to grasp complex theoretical concepts before applying them in practice.

Cooperative learning, a central approach within active learning strategies, emphasises peer-to-peer interactions that foster collaboration and strengthen problem-solving skills. Structured activities, like Think-Pair-Share, guide students to reflect individually on course content, discuss with a partner and share insights with the larger group (Johnson et al., 1994). This method promotes active engagement, enabling students to articulate their understanding, pose questions, and receive immediate feedback. Research by Karali and Aydemir (2018) highlights that cooperative learning significantly boosts student motivation, engagement, and academic performance, particularly in mathematics education. These strategies are especially effective in large classes, where traditional lectures often limit student participation and peer interaction. Recent studies emphasise the importance of cooperative learning in large classrooms, particularly in mathematics-focused courses where students frequently struggle to connect theoretical concepts to practical applications. Muthuvalu et al. (2024) demonstrated that cooperative learning strategies significantly enhance performance in large mathematics classes by promoting engagement and facilitating peer-supported understanding. This research underscores the potential benefits of integrating such strategies in engineering and mathematics courses where student interaction and practical application are essential.

Despite the clear advantages of blended and cooperative learning, their implementation in extensive mathematics courses, such as EM II, remains limited. Previous studies have focused mainly on these methods in smaller classroom settings, leaving a gap in research regarding their effectiveness in more extensive courses. This study seeks to contribute to the existing literature by exploring integrating these active learning strategies in an extensive EM II course.

Methodology

Case Study

This study investigates the effectiveness of integrating blended learning and cooperative learning techniques in the context of an extensive EM II course at UTP. The study was conducted during the January 2023 semester, targeting students majoring in Chemical Engineering (CE) enrolled in the EM II course. The course covers various topics, including ODEs and partial differential equations (PDEs), essential for engineering problem-solving.

Students were divided into two groups, one designated as the experimental group (Group 1) and the other as the control group (Group 2). While Group 1 was taught using blended and cooperative learning techniques, Group 2 followed the traditional lecture-based method. The study aimed to evaluate the impact of integrating blended learning with a collaborative learning technique, specifically Think-Pair-Share, on student engagement and academic performance compared to traditional instruction.

CL Technique Implemented

The cooperative learning technique was implemented in the experimental group:

Think-Pair-Share: Involves a three-step cooperative process. During the first step, individuals think silently about a question posed

by the instructor. Individuals pair up during the second step and exchange thoughts. In the third step, the pairs share their responses with other pairs, teams, or the entire group.

Study Design

A quasi-experimental research design was implemented with a non-equivalent control group post-test approach. This design compared the academic performance and engagement levels between the experimental group (Group 1) and the control group (Group 2). Both groups underwent the same assessments and learning objectives, with the key difference being the instructional method employed.

Table 1 Non-equivalent control group post-test quasi-experimental research design

Semester	Group	Instructional Technique	Post-Test
January 2023	1	Blended and Cooperative Learning	Yes
	2	Traditional Lecture-Based Method	Yes

Data Collection

Two types of data were collected to measure the effectiveness of the teaching techniques:

1. Quantitative Data: These data were collected through post-tests administered to both groups at the end of the semester. These tests were designed to assess students' understanding of the key topics covered in the EM II course.

2. Qualitative Data: Student perceptions of the learning process were gathered through a questionnaire administered at the end of the semester. This survey was designed to gauge student engagement, satisfaction with the instructional techniques, and perceived improvements in problem-solving skills.

Statistical Analysis

Quantitative data from post-tests were analysed using SPSS software to evaluate the statistical significance of differences in mean scores between the experimental and control groups. A *t*-test was employed to compare the performance between the two groups, and the following hypothesis was tested.

Null Hypothesis: There is no significant difference in mean scores between the experimental and control groups.

Alternative Hypothesis: The mean scores of the experimental group (Group 1) are significantly higher than the control group (Group 2).

Survey and Observation

The survey results were analysed qualitatively to capture students' feedback on the learning environment, engagement levels, and perceived benefits of the cooperative learning technique. In addition to the data collection, student participation in the experimental group was closely observed during lectures to assess their level of engagement and interaction with peers and instructors. The observations provided insights into how cooperative learning influenced classroom dynamics and facilitated active learning.

Findings and Discussions

The statistical analysis led to the rejection of the null hypothesis because the *p*-value was below 0.05. Consequently, it can be inferred that using blended and cooperative learning techniques significantly enhances students' comprehension during EM II lectures. It becomes evident that implementing the method effectively immerses students in the learning process and facilitates the cultivation of self-directed learning.

Furthermore, the observed improvement in student behaviour and interpersonal relationships underscores the potential of cooperative learning to foster a more collaborative and supportive learning environment. Developing positive interdependence, individual accountability, leadership, decision-making, and effective student communication indicate a broader educational benefit beyond improved mathematical competence.

Conclusion

The transformative teaching method integrating blended and cooperative learning strategy proved effective in enhancing student engagement, comprehension, and practical application of calculus and differential equations to solve engineering problems. The asynchronous pre-recorded lectures provided flexibility, allowing students to learn at their own pace, while the cooperative learning activities reinforced understanding through peer collaboration and interactive feedback.

These findings suggest that this integrated learning model can be effectively applied in other courses, particularly in STEM disciplines, where students often face challenges bridging the gap between theory and practice. Future research could explore extending this approach to additional mathematics and engineering courses, examining its potential to improve learning outcomes across various academic fields. Additionally, other cooperative learning techniques could be tested to assess their effectiveness in promoting student engagement and understanding in similar contexts.

References

Ballen, C.J., Wieman, C., Salehi, S., Searle, J.B., & Zamudio, K.R. (2017). Enhancing diversity in undergraduate science: Self-efficacy drives performance gains with active learning. *CBE – Life Sciences Education*, *16*(4), 16:ar56, 1-6.

Charalambides, M., Panaoura, R., Tsolaki, E., & Pericleous, S. (2023). First year engineering students' difficulties with math courses- What is the starting point for academic teachers? *Education Sciences, 13*(8), 835.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410-8415.

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1994). *Cooperative Learning in the Classroom*. Association for Supervision and Curriculum Development, Alexandria, United States.

Karali, Y., & Aydemir, H. (2018). The effect of cooperative learning on the academic achievement and attitude of students in Mathematics class. *Educational Research and Reviews*, *13*(21), 712-722.

Muthuvalu, M.S., Ali, M.K.M, Aruchunan, E., Annammala, K.V., & Sulaiman, J. Effectiveness of cooperative learning strategies in improving performance for large mathematics classes. *Proceedings of the International Conference on Advancing and Redesigning Education 2023*, Springer, Singapore, pp. 183-190, 2024.

O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The Internet and Higher Education*, *25*, 85-95.

Platonova, R.I., Orekhovskaya, N.A., Dautova, S.B., Martynenko, E.V., Kryukova, N.I., & Demir, S. (2022). Blended learning in higher education: Diversifying models and practical recommendations for researchers. *Frontiers in Education*, *7*, Article 957199.

Fostering Innovation In Mechatronics: Integrating The Double Diamond Design Thinking Model

Veeradasan Perumal*[1], Saravanan Karuppanan[1], Mark Ovinis[2]
[1]Universiti Teknologi PETRONAS, Malaysia
[2]School of Engineering and the Built Environment, Birmingham City University, United Kingdom
*veeradasan.perumal@utp.edu.my

Introduction

Mechatronics, a multidisciplinary field that combines mechanical, electrical, and computer engineering, demands innovative problem-solving skills and a deep understanding of complex systems. However, previous semesters have shown that students often struggle to create sophisticated projects that reflect the interdisciplinary nature of mechatronics. The projects lacked innovation and failed to integrate the theoretical knowledge gained during the course effectively. This issue prompted the need for a more structured and creative approach to project-based learning within the curriculum.

The Double Diamond model of design thinking, developed by the Design Council (2005), provides a systematic framework for tackling complex problems. Dividing the design process into four distinct phases – Discover, Define, Develop, and Deliver- encourages a thorough exploration of ideas and solutions. Recognising its potential to enhance creativity and project outcomes, we integrated the Double Diamond model into the mechatronics curriculum for the May 2024 semester. This manuscript presents the outcomes of this integration and evaluates the impact on student learning and project maturity.

Methodology

The Double Diamond model is a design thinking framework that helps guide the design process from the initial concept to the final product. It consists of four phases:

Discover: In this initial phase, students were encouraged to explore the problem space without preconceived notions. They conducted research, identified user needs, and gathered insights. This phase allowed students to broaden their understanding of the problem and identify potential opportunities for innovation.

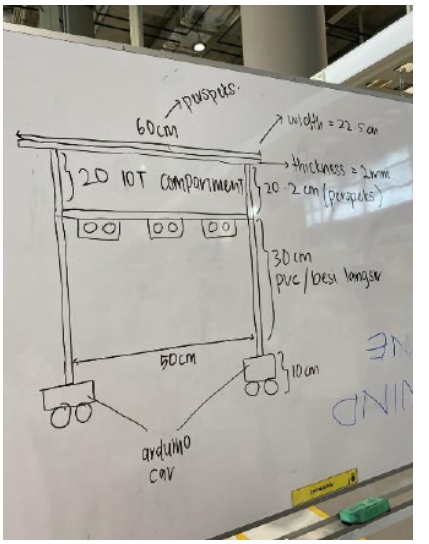


Figure 1 The example of a rough sketch at the Define stage

Define: After gathering insights, students entered the Define phase, synthesising the information to clearly articulate the problem they aimed to solve. This phase focused on narrowing down the broad insights from the Discover phase into a well-defined problem statement. Students were guided to prioritise user needs and technical feasibility, as shown in Figure 1.

Develop: In the development phase, students brainstormed and prototyped potential solutions. They were encouraged to experiment with different ideas and technologies, iterating on their designs to improve functionality and user experience. This phase was marked by creativity and exploration, emphasising rapid prototyping, as shown in Figure 2.

Deliver: The final phase, Deliver, involved refining the prototypes into final products. Students focused on optimising their designs, conducting testing, and preparing their projects for presentation. This phase ensured that the solutions were not only functional but also met the defined user needs and technical requirements, as shown in Figure 3.

By guiding students through these phases, the Double Diamond model provided a structured yet flexible approach to project development. It encouraged students to think critically and creatively, resulting in more innovative and mature projects, according to Cross (2011) and Dorst (2015).

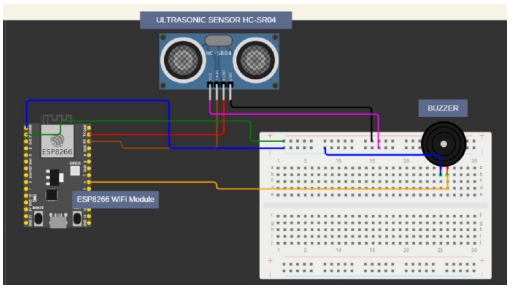


Figure 2 The example of rapid prototyping using simulation tools at the Develop stage

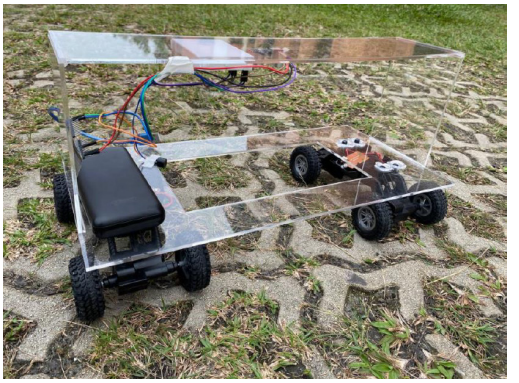


Figure 3 The example of the final prototype of the Delivery stage

Results and Discussion

Integrating the Double Diamond model in the May 2024 semester yielded significant improvements in student projects. The maturity of the prototypes developed by students was noticeably higher compared to previous semesters. Projects demonstrated a deeper integration of mechatronics principles and a more comprehensive understanding of user needs (Lawson, 2005). Students could articulate their design choices more clearly and provide more innovative solutions to the problems they addressed (Brown, 2008).

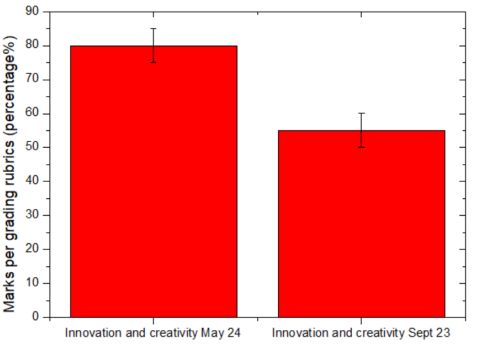


Figure 4 The marks comparison for innovation and creativity between two batches of Mechatronic students

Quantitatively, course attainment improved, with higher grades observed in the project component of the course. An in-depth analysis of the grading rubric for the mechatronics project assessment revealed that students whom the Double Diamond model guided achieved higher marks in innovation and creativity compared to the September 2023 batch, which served as the control group. Qualitative feedback from students indicated that the structured approach of the Double Diamond model helped them manage the complexity of mechatronics projects more effectively. Overall, integrating design thinking through the Double Diamond model led to enhanced learning outcomes and more sophisticated project deliverables.

Conclusion

Implementing the Double Diamond model in the mechatronics curriculum has proven to be a successful strategy for enhancing student innovation and project maturity. The model has empowered students to create more innovative and technically sound prototypes by providing a clear and structured approach to problem-solving. The improvements in the quality of student projects and overall course attainment underscore the value of integrating design thinking frameworks into engineering education. The continued use of the Double Diamond model and other design thinking approaches will be critical in fostering creativity and innovation in mechatronics education.

Acknowledgement

The author would like to thank the Universiti Teknologi PETRONAS (UTP) and the Mechanical Engineering Department for supporting this project.

References

Brown, T. (2008). Design thinking. *Harvard Business Review*, *86*(6), 84-92.

Cross, N. (2011). *Design thinking: Understanding how designers think and work.* Bloomsbury Publishing.

Design Council. (2005). The Double Diamond: A universally accepted depiction of the design process. Design Council. Retrieved from https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

Dorst, K. (2015). *Frame innovation: Create new thinking by design*. Massachusetts: MIT Press.

Lawson, B. (2006). *How designers think: The design process demystified*. Fourth Editiion. Oxfordshire: Routledge.

Mindfulness Expressive Art-Therapy (Meat) in Improving Students' Observation Skills: A Case Study from Structural Geology Course

Siti Nur Fathiyah Jamaludin*, Nur Hidayat Jamaluddin
[1] Universiti Teknologi PETRONAS
*fathiyah.jamaludin@utp.edu.my

Introduction

In bridging the gap between theoretical knowledge and practical application in the Structural Geology course under the BSc Petroleum Geoscience program, a Mindfulness Expressive Art Therapy (MEAT) activity was implemented in collaboration with UTP's Psychological and Counselling Services. This innovative approach was proposed to foster students' observation skills and promote positive mental health throughout their study. By providing a creative and mindful outlet, the activity aimed to prepare students for the challenges and intricacies of fieldwork, addressing the everyday struggle of identifying and recording significant geological features.

The MEAT activity was conducted within the first month of the students joining the course and designed as an additional effort to assist the students before attending the actual fieldwork (Figure 1). After analysing the students' performance from past semesters, MEAT was developed to encourage students to use their cognitive skills to observe details of geological essence during field data collection. The activity was conducted in students' free time in the common area provided by the counselling unit to change the environment from the usual classroom setting.

Background

Mindfulness Expressive Art Therapy (MEAT) is a therapeutic approach that combines mindfulness practices with expressive arts. Mindfulness techniques, such as meditation and deep breathing, help participants focus their attention and reduce stress. Expressive arts therapies, like visual arts, music, drama, and poetry, are used as tools for self-expression and emotional processing. By combining these two elements, MEAT promotes mental well-being, emotional regulation, and self-awareness.

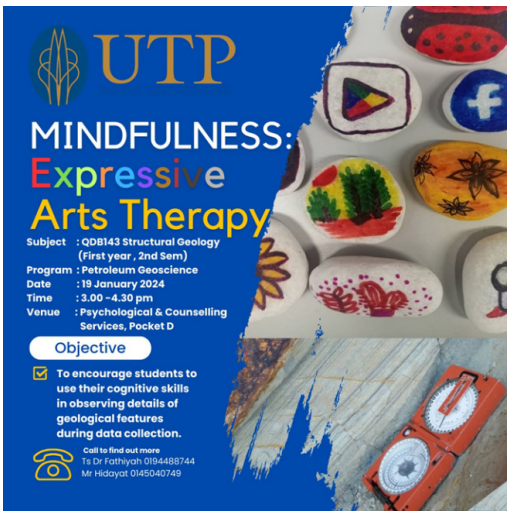


Figure 1 The poster for Mindfulness Expressive Art Therapy (MEAT) activity for BSc Petroleum Geoscience students enrolled in the Structural Geology course

MEAT empowers individuals to develop a deeper understanding of themselves and their surroundings through mindful observation, creative expression, and reflection. It fosters emotional regulation, alleviates stress and anxiety, stimulates creativity, and improves focus and attention (Rappaport, 2009). This versatile approach can be applied in various settings to benefit people of all ages and backgrounds.

Methodology

During this activity, students followed instructions from a certified counsellor. The expressive art therapy was conducted using a piece of rock for each student. In the beginning, the students need to analyse the shape and pattern of the selected rock. The students must choose one side of the rock and start drawing anything they like (Figure 2). Analysing the shape and pattern of the rock is one of the key similarities between the skills required in observing the geological outcrops in the field.



Figure 2 Mindful Expressive Art Therapy (MEAT) session with Structural Geology students (top) and examples of students' expressive art on the rocks (bottom)

After drawing their expressive art on the selected side of the rocks, the students explained the philosophy behind their drawings to their friends. During this process, students' verbal and communication skills were observed to ensure the message was delivered correctly. This is another essential key similarity between art therapy and the skills needed to communicate the scientific observations made during the fieldwork. The process flow of the MEAT activity is as per follows (Figure 3),

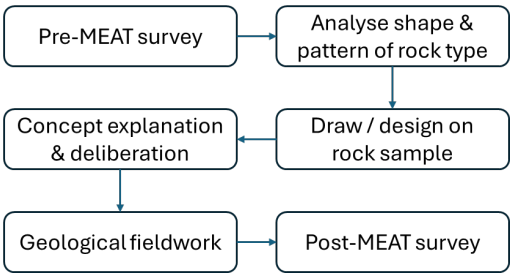


Figure 3 Process flow for the MEAT implementation

A specific survey was conducted before and after the MEAT to measure the usefulness of this activity in improving the students' observation skills, particularly in observing the geological outcrops. Pre-evaluation survey was conducted before the students participated in the art therapy. During the post-fieldwork study, an additional question was added to assess the students' perception and individual preferences on the activities that they think could have improved their observation skills. The options in the answer's selections include the MEAT and other choices such as in-class activities, fieldwork day and post-fieldwork activities.

Results

The pre-evaluation questionnaires contained two sections. In the first section, students were asked to rate their observation skills on a scale from 1 to 10 before and after taking a Structural Geology course for one semester, with 1 being the lowest and 10 being the highest. The rating on their observation skill was conducted again at the end of the course. The data indicates a

positive trend in the self-assessed observation skills of students after taking the Structural Geology course. Results show that the majority of the students showed a significant improvement in their observation skills from the beginning of the course, with the rating improved to 7-8. 4 students had also chosen a rating of 10 for their observation skills at the end of the course compared to only one student who confidently has highest observation skill rating at the beginning of the course (Figure 4). This suggests that the course effectively enhanced the students' observational abilities, leading to higher self-assessment scores.

Discussion

Another question posed at the end of the course asked the students to identify which aspects of the course they believed had enhanced their geological observation skills. Throughout the course, apart from the MEAT, the students were also exposed to in-class activities, including touching the rock samples (hand specimens and cores), seeing images in the lecture slides, conducting fieldwork activities during the fieldwork and post-fieldwork activities, including notebook preparation and group presentation (Figure 5).

Only 10% of students choose art therapy as their second option of activity that assists them in improving their observation skills, with another 15% and 20% selecting art therapy as their third and fourth choice. 65% of the students chose art therapy as the least activity that helped to improve their geological observation skills.

60% of students believe fieldwork contributes the most to improving geological observation skills. As for their second choice, 44% of students opted for post-fieldwork courses. The third choice, selected by 36% of students, involves in-class activities such as viewing images and sketching during note-taking sessions. Most students ranked courses involving hands-on experiences with rocks or core samples as their fourth choice.

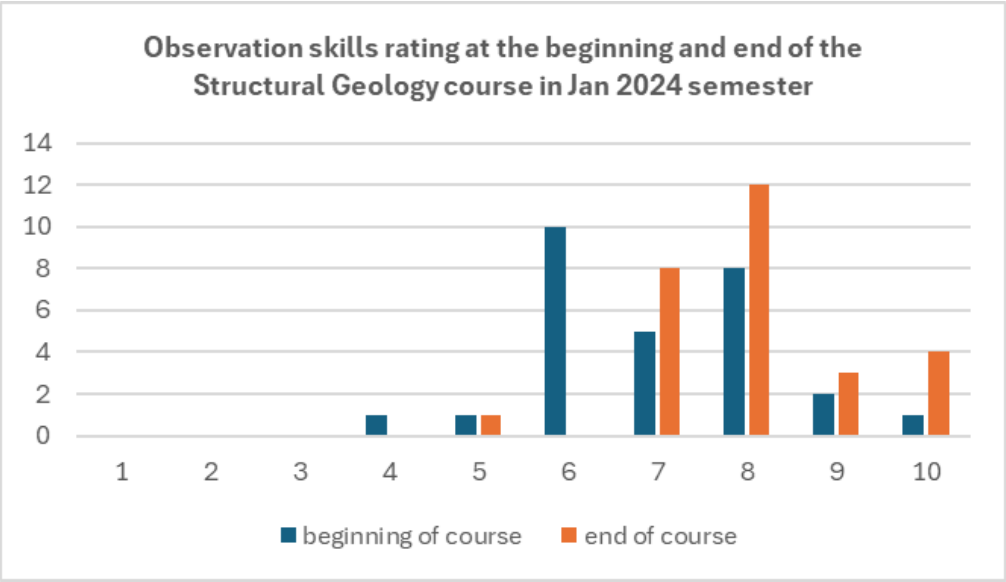


Figure 4 Pre-evaluation Survey and post-evaluation survey results on the rating from the self-assessment of the observation skills among students.

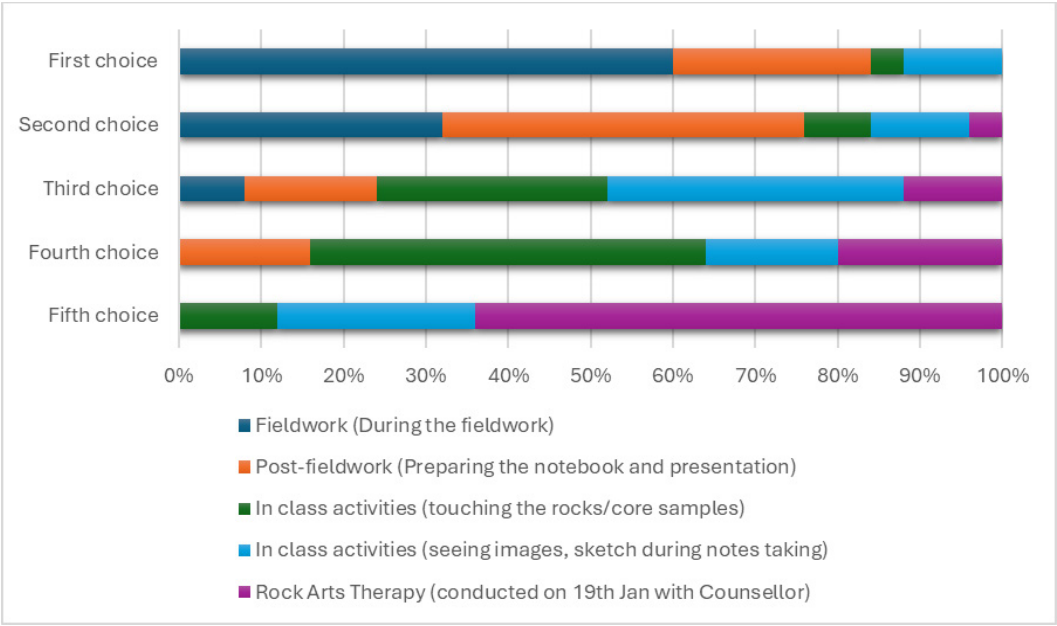


Figure 5 Post-evaluation survey results on the favourite choices of activities that helped to improve students' observation skills

Conclusions

Overall, the results show that the art therapy technique is partially meaningful and helpful in improving the students' observation skills, particularly for the geological observations in the Structural Geology subject. 10% of the students considered the art therapy helpful in improving their observation skills. Considering that the approach of adopting art therapy in teaching and learning was conducted for the first time as one of the techniques to encourage students to use their cognitive skills, several improvements and innovations could be made in applying art therapy within teaching and learning. The improvement could include specifying the theme for students to draw on the media (in this case, rock or nature) that could relate to the earth science domain instead of allowing the students to draw any random art. The art therapy activity could be conducted slightly later in the semester, just before the students attended the fieldwork. It could remain a fresh technique they learned to apply directly during the fieldwork.

Acknowledgment

The authors sincerely thank the Geoscience Department, UTP, for allowing the subjects (students) to participate in this study. Additionally, we express our appreciation to the students whose participation was invaluable to this research.

References

Ahmadi, S., Rezapour-Mirsaleh, Y. & Choobforoushzadeh, (2024). A. Effectiveness of Mindfulness-Based Art Therapy (MBAT) Utilising Watercolor Painting on Emotion Regulation, Mindfulness, and Obsessive Symptoms. *Mindfulness.15*(10), 2554-2567.

Isis, P., Bokoch, R., Fowler, G., & Hass-Cohen, N. (2024). Efficacy of a single session mindfulness-based art therapy doodle intervention. *Art Therapy, 41*(1), 11-20.

Loucks, E. B., Crane, R. S., Sanghvi, … Brewer, J. A., & Kuyken, W. (2022). Mindfulness-based programs: why, when, and how to adapt? *Global Advances in Health and Medicine, 11*.

Rappaport, L. (2009). Focusing-Oriented Art Therapy: Accessing the Body's Wisdom and Creative Intelligence. Person-Centered and Experiential Psychotherapies, London: Jessica Kengsley

Van Lith, T., Cheshure, A., Pickett, S. M., Stanwood, G. D., & Beerse, M. (2021). Mindfulness based art therapy study protocol to determine efficacy in reducing college stress and anxiety. *BMC Psychology, 9*, 134.

Enhancing Learning Experiences, Engagement, and Learning Outcomes through Short-Term Project-Based Learning: A Case Study in The Formation Evaluation Course of Petroleum Engineering

Sia Chee Wee*, M Aslam Md Yusof
Petroleum Engineering Department, Universiti Teknologi PETRONAS
*sia_cheewee@utp.edu.my

Introduction

The challenges of traditional teaching in engineering education, particularly in petroleum engineering, call for innovative, experiential learning methods that foster engagement, critical thinking, and practical problem-solving. Project-based learning (PjBL), rooted in active learning theories, addresses these challenges by providing a collaborative, inquiry-based approach that mirrors real-world industry scenarios. This study investigates a short-term PjBL intervention in a Formation Evaluation course to enhance students' technical and collaborative skills through well log data analysis and hydrocarbon volume estimation.

Educational Theories Underlying the Innovation

The PjBL approach is founded on constructivist theories, promoting student-centred learning that encourages exploration and critical thinking. It aligns with outcome-based education (OBE) principles, emphasising measurable learning outcomes crucial for engineering accreditation standards. In this context, students engage with authentic, industry-relevant tasks that reinforce theoretical knowledge with practical application.

Description of the Innovation

The innovation implemented is a four-week PjBL assignment integrated into the Formation Evaluation course. Students were tasked with analysing well log data to estimate hydrocarbon volumes in geological formations. Working under time constraints and in teams, students developed data analysis skills while making decisions based on real-world constraints. This approach aimed to provide authentic learning experiences, increase engagement, and foster collaboration.

Research and Evidence of Impact

A mixed-methods study evaluated the PjBL intervention's impact on 58 students. Data collection included a 20-item Likert-scale survey assessing students' perceptions across five dimensions: Authentic Learning Experience, Inquiry-based Learning, Collaboration, Effective Assessment, and Instructor Facilitation. The survey demonstrated high reliability (Cronbach's alpha = 0.997). Furthermore, a comparative analysis of learning outcomes between the January 2023 PjBL cohort and a control group from January 2020 indicated significant improvements in academic performance and proficiency in solving real-world problems.

Results

Survey results highlighted positive student perceptions, with an overall mean score of 4.42/5.00. Students reported that the project provided a hands-on experience that closely aligned with industry requirements.

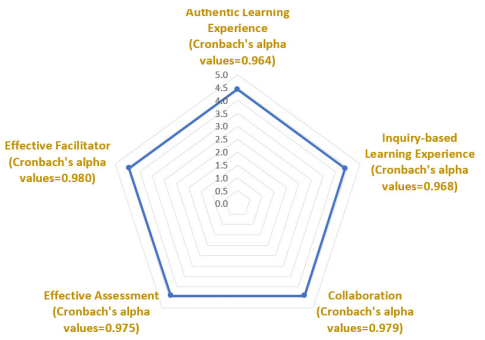


Figure 1 The high mean scores across the five PjBL dimensions, evidencing strong student approval of the method's relevance and engagement value

A t-test comparing the January 2023 PjBL cohort to the January 2020 control cohort showed a significant difference in learning outcomes ($p = 0.000488$). The results affirm that PjBL not only enhanced academic achievement but also equipped students with industry-applicable skills.

Discussion

The findings underscore PjBL's value in petroleum engineering by enabling students to engage in authentic tasks, enhancing their critical thinking and teamwork skills, and preparing them for complex engineering challenges. The strong improvement in the January 2023 cohort's outcomes validates PjBL as an effective approach in engineering curricula.

Conclusion

This study supports short-term PjBL as a potent tool for improving student engagement and learning outcomes in engineering education. By bridging theoretical concepts with practical skills, PjBL offers a pathway for preparing job-ready graduates. These insights advocate for the broader adoption of PjBL in engineering education.

Acknowledgement

The authors thank the Department of Petroleum Engineering and CeTaL at Universiti Teknologi PETRONAS for their invaluable support and the enthusiastic participation of the Formation Evaluation course students.

References

Barron, B. J., Schwartz, D. L., Vye, N. J., … Zech, L. & Brandford, J. D. (1998). Doing with understanding: Lessons from research on problem- and project-based learning. *Journal of the Learning Sciences*, 7(3-4), 271-311.

Blumenfeld, P. C., Soloway, E., Marx, R. W., et al. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26* (3-4), 369-398.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235-266.

Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., et al. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *The Journal of the Learning Sciences*, 7(3-4), 313-350.

Evaluating The Effectiveness of Project-Based Learning at Universiti Teknologi Petronas

Hassan Soleimani*, Amir Rostami, AKM Eahsanul Haque
Universiti Teknologi PETRONAS, Malaysia
*hassan.soleimani@utp.edu.my

Introduction

Education 4.0 integrates advanced technologies, personalized learning, and 21st-century skills using digital tools, AI, and data analytics to create adaptive learning environments (Halili, 2019; Hussin, 2018). Project-Based Learning (PBL), a key approach within this framework, engages students with real-world problems, promoting critical thinking, creativity, collaboration, and communication (Kokotsaki et al., 2016; Lantada, 2022). Recognized for its effectiveness in deep learning and knowledge retention, PBL is adopted globally for its practical application and interdisciplinary benefits (Boaler, 1998; Boubouka & Papanikolaou, 2013; Gibbes & Carson, 2014).

At Universiti Teknologi PETRONAS (UTP), PBL is utilized in the Scientific Inquiry course, providing a comprehensive understanding of scientific investigation principles and methodologies through local and global issues. The course includes two 90-minute weekly sessions on the scientific method, observation, hypothesis development, data analysis, and communication.

Assessments are divided into individual (40%) and group work (60%). Individual assessments include multiple-choice tests (Test 1: 15%, Test 2: 25%). Group assessments consist of a Research Proposal (15%) and a Research Project, which involves a Video Presentation (10%) and a Final Report (35%), aligning with the United Nations' Sustainable Development Goals. This structure balances individual comprehension and collaborative skills, preparing students for impactful scientific inquiry.

Methodology

We conducted a survey (Table 1) with 62 participants from the Scientific Inquiry subject to assess PBL effectiveness. Using Microsoft Excel for analysis, we examined student engagement, project complexity, collaboration, teacher facilitation, and assessment methods. The survey captured student perspectives on enthusiasm, project depth, group dynamics, and assessment fairness within the PBL context.

Additionally, we evaluated PBL's impact on learning outcomes and students' long-term trajectories, focusing on skill development and motivation. The survey also identified challenges and barriers to PBL implementation. Ratings were given from 1 to 5, with 1 indicating very low and 5 indicating very high.

By aligning survey questions with these variables, educators and institutions can comprehensively understand their PBL practices, enabling data-driven decisions to improve the learning experience and maximize the benefits of Project-Based Learning.

Table 1 Questionnaire

PBL Experience	1. How would you rate your overall experience with the Project-Based Learning (PBL) class? 2. Did you find the project-based learning approach engaging and motivating? 3. How clear the project objectives and expectations were communicated during of the class? 4. How adequately were you supported by the instructor and your peers throughout the project. 5. How do you rate your project's connectivity to the real world? 6. How do you rate the collaborative learning?
Learning Outcome	1. To what extent do you believe the PBL class improved your problem-solving skills? 2. How did the PBL class impact your ability to work in a team and collaborate with peers? 3. Were the learning outcomes of the PBL class aligned with the course objectives?
Challenges	Please rate how challenging you found the following aspects of the PBL class on a scale of 1 to 5, with 1 indicating "Not Challenging" and 5 indicating "Very Challenging." 1. Time Management 2. Team Dynamics 3. Assessment Certainty 4. Research Experience

Results and Discussion

Students' Experience during PBL

The survey data reveals highly positive student experiences in the PBL class (Table 2 and Figure 1). Key aspects such as overall experience (mean rating: 4.048), motivation and engagement (4.081), clarity of project objectives (4.048), support from instructors and peers (4.065), real-world connectivity (4), and collaborative learning (4.129) all received high mean ratings, indicating strong effectiveness of the PBL approach.

The data distribution shows slight leftward skewness and platykurtic tendencies, suggesting a concentration of favourable ratings with fewer extreme values. Standard error values, ranging from 0.093 to 0.213, indicate high precision in the sample means. These statistical parameters highlight that students' positive perceptions are consistent and reliable.

PBL's Outcome

Students reported significant gains from their PBL experience (Table 2 and Figure 2). Improved problem-solving skills received a mean rating of 3.94, teamwork ability 3.95, and alignment with course objectives 4.03, demonstrating PBL's effectiveness in achieving educational goals. Low standard error values (0.0887 to 0.2003) support the reliability of these findings. The data distribution remains relatively symmetric and moderately dispersed, indicating strong consensus among students on the benefits of PBL.

Challenges

The analysis of challenges faced by students during PBL (Table 2 and Figure 3) highlights moderate difficulties. Time management and team dynamics received mean ratings of 3.47, indicating notable challenges in these areas. Assessment certainty was rated at 3.29, suggesting some uncertainty about evaluation criteria. Research experience difficulties were rated at 3.60.

Median values align closely with mean ratings, reaffirming the central tendency of responses. Standard deviation values, ranging from 0.80 to 0.99, indicate moderate variability in student experiences. These insights into challenges provide valuable guidance for educators to target specific areas for improvement in the PBL experience.

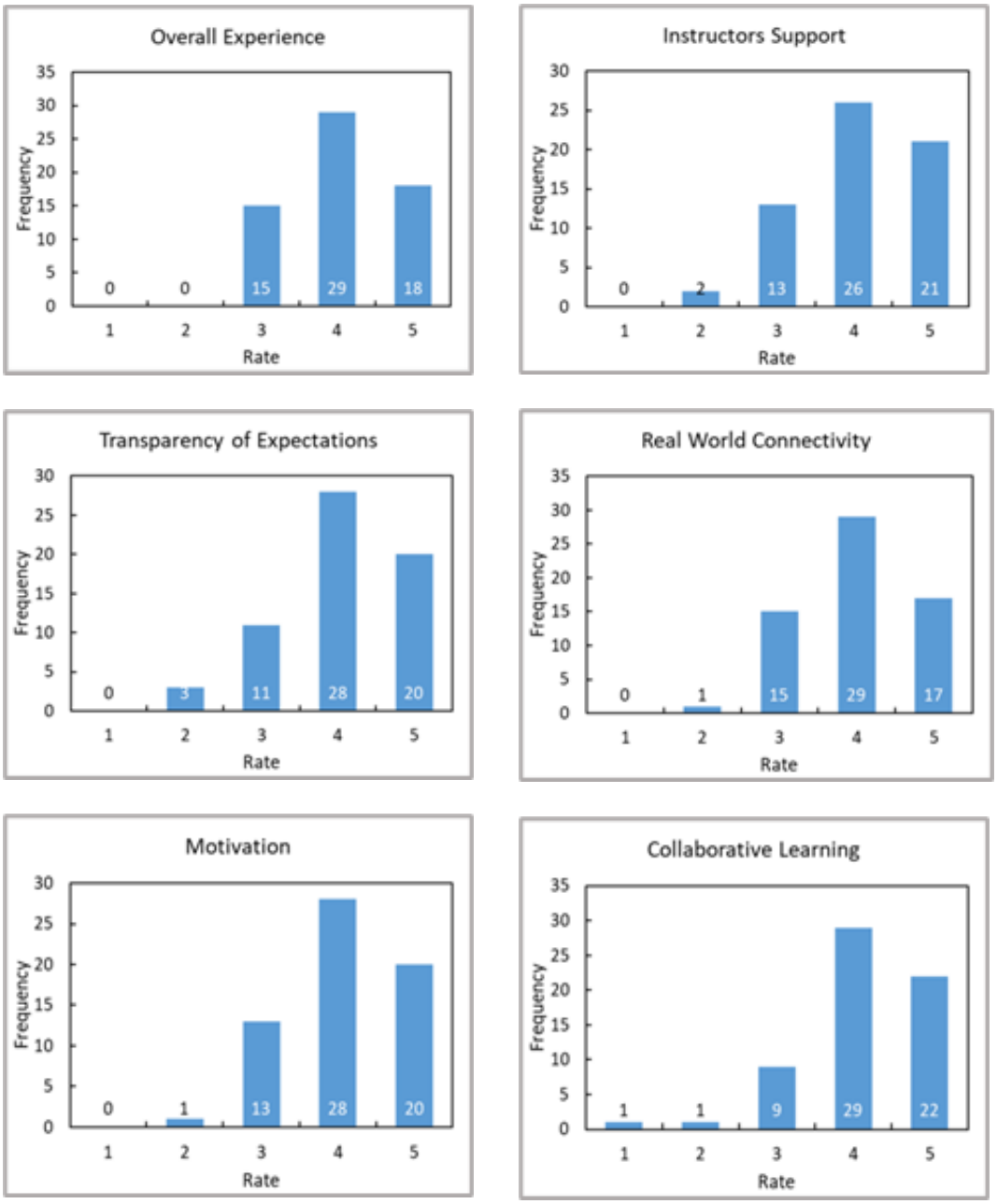


Figure 1 Experience of students during the PBL class

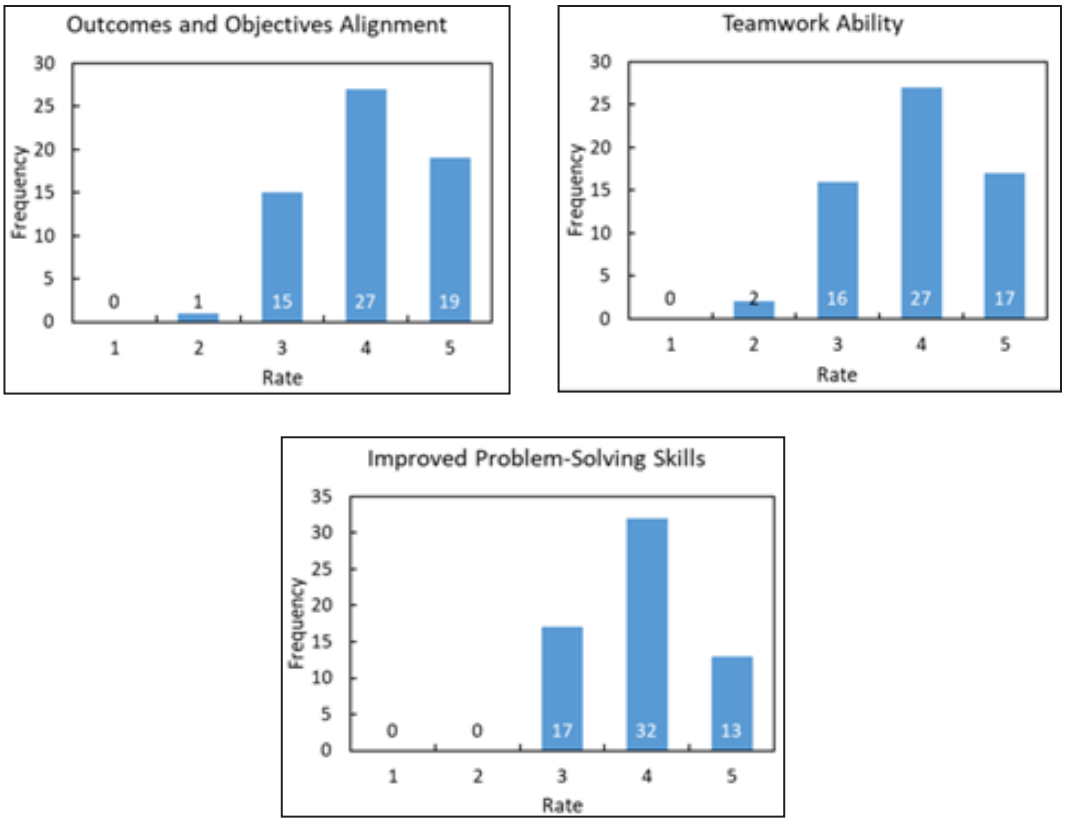
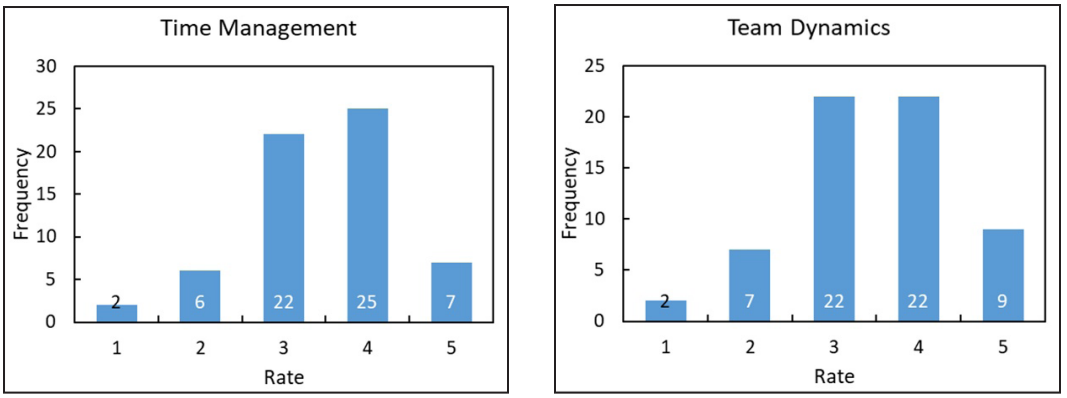


Figure 2 The outcome of PBL class: Improvement of students' capabilities and alignment of their learning outcomes to the course objectives



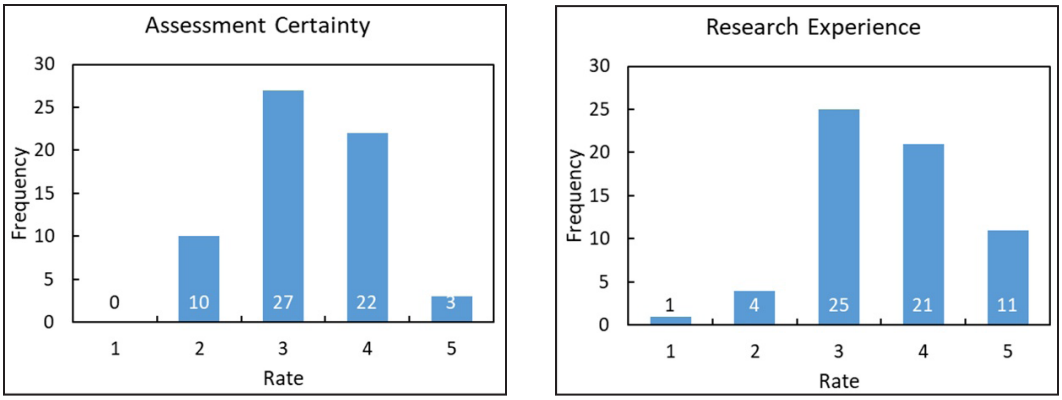


Figure 3 PBL Challenges, with 1 indicating "not challenging" and 5 indicating "very challenging

Table 2 Statistical analysis of the survey's response

Question Category	Project-Based Learning Experience						Learning Outcomes			Challenges			
Question Number (Based on TABLE I)	1	2	3	4	5	6	1	2	3	1	2	3	4
Mean	4.048	4.081	4.048	4.065	4	4.129	3.935	3.952	4.032	3.468	3.468	3.290	3.597
Standard Error	0.093	0.098	0.106	0.105	0.098	0.107	0.089	0.104	0.100	0.119	0.125	0.101	0.116
Median	4	4	4	4	4	4	4	4	4	4	3.5	3	4
Mode	4	4	4	4	4	4	4	4	4	4	4	3	3
Standard Deviation	0.734	0.775	0.838	0.827	0.768	0.839	0.698	0.818	0.789	0.936	0.987	0.797	0.914
Sample Variance	0.539	0.600	0.703	0.684	0.590	0.704	0.488	0.670	0.622	0.876	0.974	0.636	0.835
Kurtosis	-1.103	-0.603	-0.130	-0.484	-0.661	2.085	-0.893	-0.626	-0.780	0.233	-0.122	-0.506	-0.094
Skewness	-0.076	-0.360	-0.611	-0.482	-0.224	-1.111	0.088	-0.280	-0.265	-0.461	-0.330	0.024	-0.163
Minimum	3	2	2	2	2	1	3	2	2	1	1	2	1
Maximum	5	5	5	5	5	5	5	5	5	5	5	5	5
Count	62	62	62	62	62	62	62	62	62	62	62	62	62
Confidence Level (95.0%)	0.186	0.197	0.213	0.210	0.195	0.213	0.177	0.208	0.200	0.238	0.251	0.202	0.232

Conclusion

Our findings reveal that UTP students hold a highly optimistic view of their PBL experience, with mean ratings near the highest possible score. PBL effectively engages students, clarifies objectives, and fosters a collaborative learning environment. It positively impacts problem-solving skills and teamwork, aligning with course objectives. However, challenges like time management, team dynamics, assessment certainty, and research experience were noted. These insights offer opportunities for targeted improvements. Our research underscores PBL's relevance and effectiveness in Education 4.0, highlighting its potential to equip students with essential 21st-century skills and practical problem-solving abilities.

References

Boaler, J. (1998). Open and closed mathematics: Student experiences and understandings. *Journal for research in mathematics education, 29*(1), 41-62.

Boubouka, M., & Papanikolaou, K. A. (2013). Alternative assessment methods in technology enhanced project-based learning. *International Journal of Learning Technology, 8*(3), 263-296.

Gibbes, M., & Carson, L. (2014). Project-based language learning: an activity theory analysis. *Innovation in Language Learning and Teaching, 8*(2), 171-189.

Halili, S. H. (2019). Technological advancements in education 4.0. *The Online Journal of Distance Education and e-Learning, 7*(1), 63-69.

Hussin, A. A. (2018). Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies, 6*(3), 92-98.

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools, 19*(3), 267-277.

Lantada, A. D. (2022). Engineering education 5.0: Strategies for a successful transformative project-based learning. *In Bouezzeddine, M., Insights into Global Engineering Education After the Birth of Industry, London: IntechOpen.*

Enhancing Practical Competency and Teamwork in Petroleum Engineering Students through Open-Ended Laboratory Assessments

Nur Asyraf Md Akhir*, Sia Chee Wee, Muhammad Aslam Md Yusuf
Faculty of Engineering, Universiti Teknologi PETRONAS, Malaysia
*asyraf.akhir@utp.edu.my

Introduction

The Reservoir Rock and Fluid Properties Laboratory course is offered to first-year Petroleum Engineering students during their second semester as part of the four-year program. This course runs concurrently with the Reservoir Rock Properties and Reservoir Fluid Properties subjects over a 12-week semester. The course covers basic principles and laboratory work, which are essential for the students' theoretical and experimental understanding throughout their studies. These skills form the foundation for their final-year experimental projects and help develop their practical competency.

Three Course Learning Outcomes (CLOs) were established for this course, as outlined in Table 1. These CLOs include an appreciation of health, safety, and environmental (HSE) factors, laboratory data analysis and interpretation, and practical communication skills through both verbal and written reports.

According to the Board of Engineers Malaysia (BEM) and the Engineering Accreditation Council (EAC) under Criterion 3: Academic Curriculum (Laboratory Works), students must receive sufficient laboratory experience to complement and reinforce engineering theory. Laboratory work also aids in developing students' practical competence. Much of laboratory work is expected to be open-ended, encouraging future engineers to gain confidence in solving complex engineering problems.

Table 1 CLO Description

CLO Name	CLO Description
CLO 1	Appreciate the health, safety, and environment of equipment and laboratory equipment.
CLO 2	Analyse and interpret reservoir rock and fluid laboratory data.
CLO 3	Communicate effectively in verbal and written form when reporting the research outcome.

In line with EAC criteria, an open-ended laboratory assessment has been introduced in the Reservoir Rock and Fluid Properties course. Previously, this laboratory work was embedded in the Rock and Fluid Properties subject, which carried three credit hours. It has now become a stand-alone subject with one credit hour. The students are systematically assessed individually and in groups, supervised by the laboratory coordinator (academic staff), laboratory technicians, and trained graduate assistants. Nine experiments, including one open-ended lab, are designed to complement the engineering theory taught in lectures. These

experiments help students develop practical competency, foster collaborative learning, encourage creativity and innovation, promote independent and group work, and enhance communication skills.

This study explores students' ability to manage collaborative projects, their creativity in working as a group and individually, and how these skills prepare them for future engineering roles. It also examines their written and oral communication abilities, proficiency in instrumentation skills, and critical design thinking in open-ended laboratory procedures and analysis. The aim is for students to implement classroom knowledge in practical settings for a deeper understanding.

Related Work

Laboratory courses are an integral component of engineering education, particularly in fields such as petroleum engineering, where practical experience must complement theoretical knowledge. Implementing laboratory-based courses, such as Reservoir Rock and Fluid Properties (RFP) labs, enhances students' understanding of fundamental principles while promoting essential skills such as teamwork, communication, and critical thinking (Walsh et al., 2022).

Role of Laboratory Courses in Engineering Education

Engineering laboratory courses are designed to bridge the gap between theoretical knowledge and practical applications (Hofstein & Lunetta, 2004). They offer students the opportunity to engage with real-world engineering problems, helping to build competencies in data analysis, problem-solving, and collaboration (Streveler et al., 2008). These labs are also critical in developing safety awareness, particularly in disciplines such as petroleum engineering, where laboratory users must adhere to strict health, safety, and environmental (HSE) standards (Salim et al., 2009).

The shift from traditional to open-ended laboratory tasks, as described in this study, reflects current pedagogical trends in engineering education. Open-ended labs allow students to design experiments, fostering creativity and innovation (Kofli et al., 2012). Moreover, the hands-on experience in managing complex experimental setups and data analysis mirrors real-world challenges, preparing students for future professional roles (Sheppard et al., 2009).

Reservoir Rock and Fluid Properties Laboratory

The Reservoir Rock and Fluid Properties (RRFP) laboratory is an essential part of the petroleum engineering curriculum. It focuses on key principles such as porosity and permeability measurements, interfacial tension, fluid viscosity, and density (Ahmed, 2010). Understanding these properties is crucial for petroleum engineers, as they directly influence the behaviour of oil and gas reservoirs (Dake, 2001).

Measurement techniques like helium porosimetry, saturation methods for porosity, or PoroPerm systems for permeability are standard practices in the industry (Schön, 2015). These experiments provide students with the foundational knowledge to analyse subsurface formations and fluid flow. Laboratories that focus on such techniques reinforce theoretical knowledge and develop students' technical skills in utilising industry-standard equipment (Tiab & Donaldson, 2012).

Introducing an open-ended laboratory assessment in the course promotes higher-order thinking skills. According to Prince and Felder (2006), open-ended tasks encourage students to engage in experimental design, critical evaluation, and essential research and engineering practice skills. By requiring students to devise their methodologies, these assessments also mirror the autonomy they need in professional settings (Jonassen, 2011).

Health, Safety, and Environment (HSE) in Laboratory Work

Incorporating HSE principles into laboratory work is vital to engineering education, especially in fields where safety is a significant concern. The implementation of the Laboratory Management and Safety Module at UTP, as described in the study, is consistent with best practices in engineering education. Ensuring that students are trained and assessed in HSE practices aligns with global trends where safety training is mandatory in many engineering disciplines (Bęś & Strzałkowski, 2024).

Previous studies emphasise the importance of safety training in fostering a safety-first culture among students (Bęś & Strzałkowski, 2024). This approach is critical, as students well-versed in HSE protocols are more likely to apply these principles in their future professional roles (Bęś & Strzałkowski, 2024). Furthermore, safety training not only helps students minimise risks in the lab but also instils in them a sense of responsibility toward their future work environments (Goetsch, 2018).

Assessment Methods in Engineering Laboratories

The assessment methods used in laboratory courses ensure students meet the desired learning outcomes (Hunter et al., 2003). In this case, the course is assessed through three CLOs: appreciation of HSE standards, laboratory data analysis, and communication skills. Assessment of HSE knowledge through written reports helps ensure students understand safety procedures, which is essential in engineering disciplines (Zhao et al., 2023; Zhao et al., 2018).

Technical reports and oral presentations are widely recognised as practical tools for assessing communication skills in engineering education (Salim et al., 2012). According to Turner and Simon (2013), students who are regularly tasked with writing technical reports or presenting their findings tend to develop stronger communication skills essential for professional success. The inclusion of an open-ended laboratory assessment is also supported by research showing that such assessments encourage deep learning and the development of problem-solving skills (Rio & Rodriguez, 2022).

Research Methodology

Reservoir Rock and Fluid Properties Laboratory Course Implementation

In the Reservoir Rock and Fluid Properties (RFP) laboratory course, students work in groups of no more than five members. Under the supervision of laboratory technicians and trained graduate assistants, students conduct eight main laboratory experiments and one open-ended laboratory task. The list of experiments covering the principles of reservoir rock and fluid properties measurements is shown in Table 2.

Students conduct two sets of experiments each week. Depending on the total number of groups, two lab slots are available each week, comprising two experiments completed within two hours. Most experiments utilise essential equipment typically used in petroleum engineering. Generally, students complete four slots of experiments covering the eight main tasks, followed by one consolidation week dedicated to preparing for the open-ended laboratory task. During this week, they develop the methodology and procedures for the lab and seek prior approval from the laboratory instructors. While the objectives are pre-set, students are responsible for creating their methods and procedures for the open-ended lab. Before the semester begins, graduate assistants are trained to operate the equipment and analyse data. At the start of the semester, the laboratory coordinator briefs the students on the timeline, schedule, and assessments. This briefing also introduces students to the open-ended lab activity. At the University of Technology Petronas (UTP), the Laboratory Management and Safety (LMG) module is

currently being implemented. All laboratory users must complete and pass the LMG safety module and assessment before being permitted to work there. Students must enrol in the LMG Safety Passport Module, complete the learning module, and pass the assessment before using the laboratory facilities.

Upon successful completion, students receive certification, valid for one year, which must be renewed upon expiration. It is a notable improvement over the previous process, which only required students to attend a safety briefing. The new training and assessment approach ensures that students can apply their knowledge of HSE practices, an essential component of future engineering work. Furthermore, this serves as part of the assessment for CLO 1, which involves the safety report.

Table 2 List of Experiments

Lab	Experiment
Lab 1	Porosity Measurement using a Helium Porosimeter
Lab 2	Porosity Measurement using the Saturation Method
Lab 3	Permeability Measurement using the PoroPerm System
Lab 4	Permeability Measurement using Liquid
Lab 5	Interfacial Tension Measurement
Lab 6	The Measurement of the Density of Brine of Different Salinity, Distilled water, and Oil Samples
Lab 7	Liquid Viscosity
Lab 8	Boyle's Law
Lab 9	Open Ended Laboratory Assessment: Grain Density Measurement and Sand-Packed Porosity Determination

Assessment

The course is assessed based on three Course Learning Outcomes (CLOs), as outlined in Table 1: appreciation of health, safety, and environment (HSE) principles; laboratory data analysis and interpretation; and communication skills through verbal and written reports. These CLOs are evaluated through several assessment methods, summarised in Table 3. CLO 1 is assessed through an HSE report, contributing 10% of the overall grade. Students must understand and apply HSE standards and regulations during laboratory work and identify precautionary measures when handling chemicals and equipment.

CLO 2 is assessed through laboratory technical reports, contributing 50% of the total grade. This CLO primarily focuses on data analysis and interpretation. According to the assessment rubric, the highest percentage of marks is allocated to the reports' literature review, methodology, results, and discussion sections. CLO 3, which evaluates communication skills through verbal and written reports, is divided into an open-ended laboratory assessment (15%) and an oral assessment (25%). The open-ended lab is assessed based on practical work and a written report. Students are given objectives and have 1-2 weeks to prepare a feasible methodology before experimenting. For example, students receive granular samples and must determine the grain density with a target porosity of 35% in their sand packing.

Practical assessment includes the selection of experimental procedures, data collection, analysis, and the students' independence in conducting the lab work. It also evaluates teamwork, participation, and contribution. The written report is assessed using the

same rubric as the technical reports. For the oral assessment (worth 25%), students are evaluated both individually and as a group. The assessment rubric focuses on applying concepts in their experiments, methodology, results, and discussion. Questions are based on the nine laboratory experiments conducted throughout the semester, and students answer individually and as part of a group.

Table 3 CO-Assessment Mapping and their weightage

CO Name	Assessment	Percentage (%)	
		Individual	Group
CO1	HSE Report	10	-
CO2	Laboratory Technical Reports	-	50
CO3	Open-ended Laboratory Assessment	-	15
CO3	Oral Assessment	10	15
	Total	20	20

Based on the results, students generally performed well in the HSE report section, indicating a good understanding of HSE implementation, likely due to the prerequisite HSE training. In the open-ended laboratory practical assessment, most students developed effective experimental procedures, collected data efficiently, and analysed results accurately. While some students remained somewhat dependent on lab assistants, most teams performed well in teamwork, participation, and contribution. During the oral assessment, most students were able to answer questions effectively. Those who achieved the highest individual marks generally performed well in the classroom throughout the semester, reflecting a strong understanding of both theoretical and practical concepts.

Results and Discussions

The data were analysed for 97 students (organised into 19 groups), focusing on their overall performance based on the assessment mapped to their Course Learning Outcomes (CLOs). Figure 1 illustrates that most students demonstrated a solid understanding and effective implementation of Health, Safety, and Environment (HSE) protocols while handling chemicals and equipment in the laboratory. Approximately 84.54% of students achieved A and A- grades in this area. The strong performance in the HSE report section indicates that students have internalised the importance of HSE, likely due to the prerequisite HSE training.

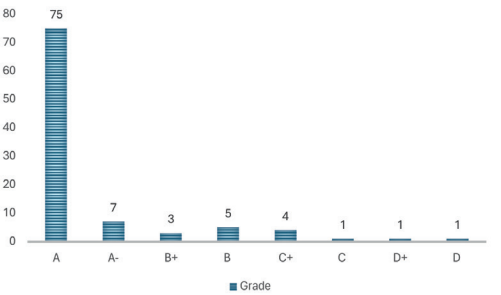


Figure 1 Students' Individual Performance for the CLO1

Figure 2 presents the students' group performance based on their technical laboratory reports, which are mapped to CLO 2. In this assessment, students are expected to analyse laboratory data and demonstrate their understanding of rock and fluid properties. Most groups earned A- grades, with one group receiving a C+. The group that received the C+ struggled with data interpretation and had difficulty relating their findings to the theoretical concepts covered in the classroom.

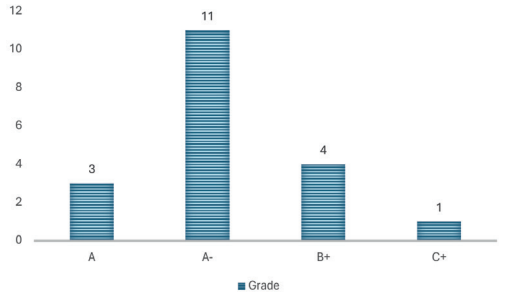


Figure 2 Students' Group Performance for the CLO2

For the open-ended laboratory practical assessment, mapped to CLO 3, the results were divided into two categories: practical performance and written reports, as shown in Figure 3. In the practical assessment, students were evaluated on their ability to develop a methodology, apply it in the laboratory, analyse the data, and work independently. Additionally, teamwork, participation, and contribution were assessed. It was observed that, during the lab sessions, some groups still relied on assistance from the trained graduate assistants. However, the groups that scored the highest were those that excelled in teamwork, participation, and contribution.

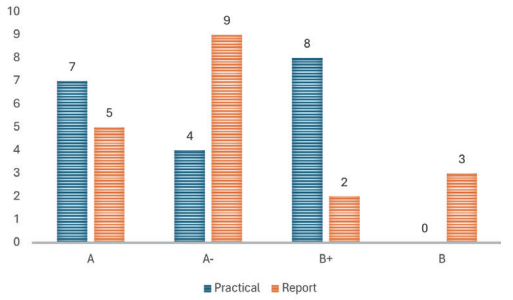


Figure 3 Students' Group Performance for the CLO3

Figure 4 displays the distribution of marks for both individual and group components of the oral assessment, also mapped to CLO 3. The assessment covered concepts, methodology, and the results and discussion. Although most students performed equally well in answering the questions, those who achieved the highest individual marks were generally those who had consistently excelled in the classroom throughout the semester.

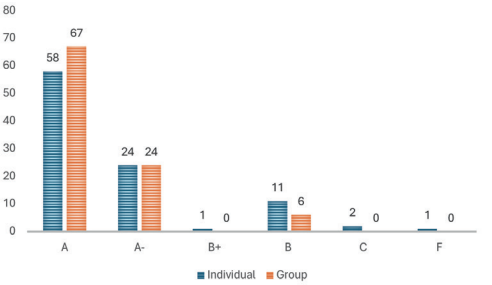


Figure 4 Students' Individual and Group Performance for the CLO3

Conclusion

The RRFP laboratory course effectively enhances students' understanding of key petroleum engineering concepts, particularly in HSE implementation, data analysis, and communication skills. The analysis of student performance shows strong attainment in HSE largely attributed to prior HSE training. The technical report assessment highlighted students' ability to relate practical findings to theoretical concepts, though a few groups struggled with data interpretation. Open-ended laboratory assessments demonstrated student creativity and teamwork, with some still relying on external support. Overall, the course is vital in developing students' practical competency, teamwork, and problem-solving skills essential for future engineers.

Acknowledgement

We would like to express our sincere gratitude to the laboratory technicians, trained graduate

assistants and Petroleum Engineering Department for their invaluable guidance and support throughout the course. Their expertise, patience, and dedication in ensuring the smooth execution of the experiments have greatly contributed to the student's learning experience and the success of this study.

References

Ahmed, T. (2010). *Reservoir Engineering Handbook.* Fourth Edition, Ar-Rayyan, Qatar: Gulf Professional Publishing.

Bęś, P. & Strzałkowski, P. (2024). Analysis of the effectiveness of safety training methods. *Sustainability*, *16*(7), 2732.

Dake, L. P. (2001). *Fundamentals of Reservoir Engineering*. Amsterdam: Elsevier.

Goetsch, D.L. (2018). *Occupational Safety and Health for Technologists, Engineers, and Managers.* New Jersey: Pearson.

Hunter, C., Mccosh, R. & Wilkins, H. (2003). Integrating Learning and Assessment in Laboratory Work. *Chemistry Education Research and Practice*, 4(1), 67-75.

Hofstein, A. & Lunetta, V.N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, 88(1), 28-54.

Jonassen, D.H. (2011). *Learning to Solve Problems: A Handbook for Designing Problem-Solving Learning Environments*. Oxfordshire: Routledge.

Kofli, N.T., Badar, S.N., Abd. Rahman, N. & Sheikh Abdullah, S.R. (2012). Nurturing Innovative and Creativity through Open Ended Laboratory: JKKP Experience. *Procedia – Social and Behavioral Sciences*, 56, 713-717.

Prince, M.J. & Felder, R.M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, 95(2), 123-138.

Rio, T.G. & Rodriguez, J. (2022). Design and assessment of a project-based learning in a laboratory for integrating knowledge and improving engineering design skills. *Education for Chemical Engineers,* 40, 17-28.

Salim, K.R., Puteh, M. & Mohd Daud, S. (2012). Assessing students' practical skills in basic electronic laboratory based on psychomotor domain model. *Procedia – Social and Behavioral Sciences*, 56, 546-555.

Salim, K.R., Puteh, M. & Mohd Daud, S. (2009). Review of the Current Laboratory Practice in Malaysian University: A Preliminary Study". In: International Conference on Engineering and Education in the 21st Century, Kuching, Sarawak, Malaysia.

Schön, J.H. (2015). *Physical Properties of Rocks: Fundamentals and Principles of Petrophysics*. Elsevier.

Sheppard, S.D., Macatangay, K., Colby, A. & Sullivan, W. M. (2009). *Educating Engineers: Designing for the Future of the Field.* Jossey-Bass.

Streveler, R.A., Litzinger, T.A., Miller, R.L. & Steif, P.S. (2008). Learning conceptual knowledge in the engineering sciences: Overview and future research directions. *Journal of Engineering Education*, 97(3), 279-294.

Tiab, D. & Donaldson, E.C. (2012). *Petrophysics: Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties.* Fourth Edition. Arr-Rayyan, Qatar: Gulf Professional Publishing.

Walsh, C., Lewandowski, H.J. & Holmes, N.G. (2022). Skills-focused lab instruction improves critical thinking skills and experimentation views for all students. *Physical Review Physics Education Research*, 18(1), 010128.

Zhao, J., Cui, H., Wang, G., Zhang, J. & Yang, R. (2023). Risk assessment of safety level in university laboratories using questionnaire and Bayesian network. *Journal of Loss Prevention in the Process Industries*, 83, 105054.

Zhao, C., Tang, X. & Yuan, L. (2018). MAGDM Method with Pythagorean 2-Tuple Linguistic Information and Applications in the HSE Performance Assessment of Laboratory. *Mathematical Problems in Engineering*, 2018, 1-9.

Safetyverse: Virtual Environment Development for Safety Training and Awareness

Muhammad Arif Hakimi Ismadi*, Savita K.Sugathan
Universiti Teknologi PETRONAS, Malaysia
*arif_20000575@utp.edu.my

Introduction

Laboratory safety training is a critical aspect of ensuring the well-being of personnel and the effective operation of laboratory environments. It includes a variety of methods, guidelines, and processes intended to reduce risks, stop mishaps, and advance a safety-conscious society. However, the traditional laboratory safety training methods have been criticised for lacking actual skill development and hands-on experience, which are essential for ensuring the safety of laboratory personnel (Babalola et al., 2023).

Lectures, manuals, and demonstrations are the main components of traditional laboratory safety training methods, which might not fully prepare people for crises and dangers in the real world. Furthermore, these approaches frequently lack actual skill development and hands-on experience, which leaves participants with gaps in their knowledge and competency. As a result, people might not be completely prepared to recognise and reduce hazards, handle emergencies, or follow safety procedures in lab environments.

Office safety is equally crucial to creating a safe and healthy work environment in a laboratory setting. Office safety training covers policies and procedures to reduce workplace accidents, enhance ergonomics, and prepare employees for emergency evacuations. Similar to laboratory safety training, traditional office safety training approaches have drawbacks. They frequently rely on static presentations and manuals that don't engage employees effectively.

An increasing interest has emerged in adopting advanced safety training strategies that leverage innovative technologies to address these challenges. While augmented reality (AR) and virtual reality (VR) have gained attention for their immersive capabilities, this project focuses on using web-based metaverse solutions, specifically the Spatial.io platform. Spatial.io provides a web-based metaverse environment that enables collaborative and interactive training experiences without requiring specialised equipment, such as VR headsets or augmented reality devices.

Traditional safety training, characterised by passive learning through lectures and manuals, often lacks hands-on experience, leading to gaps in knowledge retention and practical skills. This project significantly advances safety education by offering an immersive, accessible platform that simulates real-life safety hazards using web-based metaverse technology in laboratory and office settings. It revolutionises the current safety training methods, improving engagement, motivation, and practical skill application, which is crucial for ensuring safety compliance and reducing workplace accidents.

Hence, the project aims to close the gap between theoretical knowledge and practical skills by utilising gamification principles and

the capabilities of Spatial.io. It will enable individuals to successfully navigate safety dangers and crises in real-world laboratory and office settings (Zheng, 2022). Along the way, participants will communicate with peers, navigate virtual laboratory and office environments, finish interactive training modules, and get incentives for their accomplishments.

Methodology

The project follows Agile methodology, a flexible and iterative approach to development. Agile allows for continuous feedback, adjustments, and incremental progress, ensuring that each phase—from planning to deployment—aligns with user needs and stakeholder expectations.

Key elements include frequent meetings with UTP HSE and iterative User Acceptance Testing (UAT), enabling continuous improvement based on real-time feedback. This method ensures that the final product is user-centred and adaptable, optimising the virtual safety training platform's effectiveness and usability.

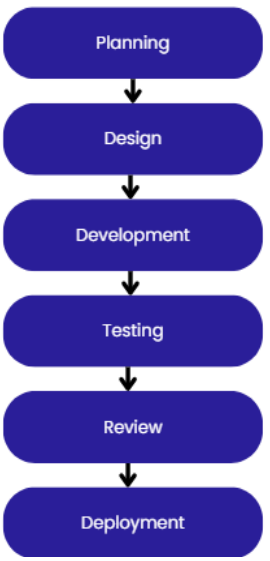


Figure 1 Phases in developing the project

Planning Phase

The project followed the Agile framework, starting with extensive requirement gathering to define objectives and refine the scope. Stakeholder feedback favoured a web-based metaverse platform and led to expanding the scope to include both laboratory and office safety training, incorporating gamification elements to enhance engagement.

Design Phase

In the design phase, hand-drawn sketches outlined the layouts and features of the virtual environments, with Agile principles allowing for adjustments based on feedback.

Development Phase

During development, designs were turned into interactive virtual training environments using Unity. Training content was developed with input from the UTP HSE department, chemical engineering students, and online resources, covering office and laboratory safety through gamified quests and quizzes on Kahoot.

The program sutilised Spatial.io and Unity features for interactive elements, avatar teleportation, and custom avatars, while advanced Unity tools like Animator Controller and visual scripting enabled complex interactions and realistic animations. Kahoot integration further boosted engagement and learning effectiveness through interactive quizzes and feedback.

Testing Phase

The testing phase ensured functionality and user-friendliness through unit and user acceptability testing, leading to iterative refinements guided by Agile methods.

Review Phase

The review phase confirmed that the program met stakeholder expectations through sprint reviews and quality assurance, while iterative improvements adapted the program to evolving needs.

Deployment Phase

Finally, the deployment phase moved the training program to Spatial.io, involving final validations and performance checks. Post-deployment, the platform was monitored and maintained with automated alerts, backups, and updates to ensure a smooth user experience.

Results and Discussion

Quadrant	Input
High Impact, High Feasibility	• Better User prompt when starting a quest • Make informative videos non-skippable • Make areas restricted before starting a quest • Help feature/provide guide • Add timer to time-sensitive events (e.g fire evacuation)
High Impact, Low Feasibility	• Add an informative NPC • Interaction with game elements
Low Impact, High Feasibility	• Add more trivia or informative information • Add narrator/voice over • Add more sound effects & background music
Low Impact, Low Feasibility	• Mini games to test knowledge • More sudden quests

Figure 2 Outcome of idea prioritisation matrix



Figure 3 UAT with DLSU students

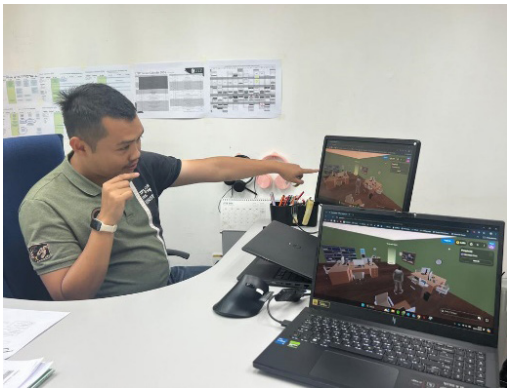


Figure 4 UAT with UTP HSE Department

User acceptance testing (UAT) and feedback analysis were crucial for refining the virtual training environment. Initial results indicated high user engagement and satisfaction, with improved knowledge retention and motivation. Insights from interactive quizzes and performance evaluations informed ongoing optimisation of the platform. Participants used an idea prioritisation matrix to assess solutions by categorising them into quadrants based on impact and feasibility to rank ideas by their potential for successful development and implementation.

This project introduces an original approach to safety training by integrating the Spatial.io metaverse platform and gamification elements into the training modules. Unlike conventional training methods, this metaverse-based platform incorporates game-like features, such as missions, rewards, and social interaction, which foster active participation and enhance learning outcomes. Office safety training and laboratory safety further broaden the scope and impact of this innovative solution.

The results indicate that the SafetyVerse platform successfully addresses the primary shortcomings of traditional safety training methods. Participants reported greater motivation and engagement attributed to the interactive and game-like nature of the

platform. The virtual environments enabled users to gain practical experience in a safe and controlled manner, leading to enhanced confidence in handling safety procedures. It successfully integrated interactive features and scenario-based simulations, bridging the gap between theory and practice.



Figure 5 Layout of SafetyVerse in Metaverse



Figure 6 Office setting in Metaverse

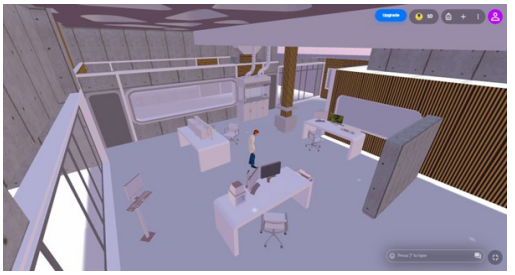


Figure 7 Laboratory setting in Metaverse

The program adhered to safety regulations and industry best practices, demonstrating its effectiveness in enhancing workplace safety education and meeting the project's objectives. Further discussion highlights the need for future updates, including expanded content coverage and evaluation of the long-term impact on safety behaviour.

Contributions

1. Teaching and Learning
   The SafetyVerse project introduces a new safety education method that uses gamification and immersive technology to enhance engagement and practical skills development. The web-based metaverse platform simulates real-world safety scenarios, improving knowledge retention and effectiveness for students and professionals.

2. Innovation in Safety Training Delivery
   The project introduces an accessible, flexible safety training platform using Spatial.io and Unity, promoting active participation and continuous learning through a gamified approach, thereby enhancing safety awareness and compliance among a wider audience.

3. Research and Future Application
   The project explores the use of immersive technologies in educational and safety training, demonstrating the potential of the Metaverse for experiential learning in various domains, paving the way for future studies.

Conclusion

This project represents a significant step in smodernising safety training for lab and office environments. It addresses the shortcomings of traditional methods by providing an immersive, interactive learning experience that bridges the gap between theory and practice. The project successfully achieved its goals by creating a comprehensive metaverse environment, ensuring ongoing updates for safety compliance,

and evaluating current training techniques. The SafetyVerse project contributes to occupational safety and educational technology by offering a scalable, innovative platform that improves the delivery and effectiveness of safety training. It provides a framework for integrating metaverse technology and gamification into education, setting a new standard for interactive learning environments in safety training.

Acknowledgement

The author would like to acknowledge the grant funder, Yayasan Universiti Teknologi PETRONAS (YUTP) [015LC0-523], for funding this research paper.

References

Babalola, A., Manu, P., Cheung, C., Yunusa-Kaltungo, A., & Bartolo, P. (2023). Applications of immersive technologies for occupational safety and health training and education: *A systematic review. Safety Science*, *166*, 106214.

Zheng, Y. (2022). Empowering Future Education: Learning in the EduMetaverse. *Educational Information Technology Journal, 55*(2), 292-295.

Tearning: Blending Teaching and Learning Into A Unified Student-Centered Educational Experience

Daniel Tonye Oyefidein*, Precious Ada Josiah, Shamsuddeen Adamu
Universiti Teknologi PETRONAS , Malaysia
*daniel_24001664@utp.edu.my

Introduction

In present-day education, there is an increasing need to bridge the gap between teaching and learning, which have traditionally been viewed as separate processes. Conventional educational models often position teachers as the primary sources of knowledge while students passively absorb information, creating a disconnect that impedes deep learning and critical thinking (Hannafin & Land, 2000). This paper introduces the concept of 'tearning', an innovative hybrid model that integrates teaching and learning into a cohesive, student-centred experience. Drawing inspiration from the Serbian verb "Učiti", which means both 'to teach' and 'to learn'. The tearning model advocates for a paradigm shift in education, wherein teaching and learning occur concurrently in an interconnected, continuous process (Marlina et al., 2023).

The tearning model envisions the classroom as a dynamic environment where students and teachers actively engage in the learning journey. Unlike traditional methods emphasising one-way knowledge transmission, tearning prioritises collaborative learning, critical thinking, and real-world problem-solving, placing students at the heart of the educational experience (Affandi & Sukyadi, 2016). By employing a combination of pre-assessment, differentiated instruction, and project-based learning, tearning aims to foster a more adaptive and personalised approach to education (English & Kitsantas, 2013).

Related Works

In conventional educational frameworks, students often assume passive roles as recipients of knowledge, a model criticised for fostering rote memorisation rather than cultivating critical thinking and problem-solving abilities (Freire, 1996). The "banking model" of education is where students are compelled to memorise information without engaging in meaningful interactions with the content. Supporting this critique, Marton and Säljö (1976) demonstrated that reliance on routine memorisation results in surface-level learning, which constrains the application of knowledge to novel contexts. Furthermore, (Brookhart, 2010; Ryan & Deci, 2000) contend that such pedagogical approaches diminish student autonomy, leading to disengagement and reduced motivation.

Innovative instructional models such as project-based learning (PBL), experiential learning, and inquiry-based learning (IBL) have gained prominence in response to these challenges. PBL, in particular, empowers students to engage in authentic projects, enhancing critical thinking and collaborative skills. Barron and Darling-Hammond (2008) and Thomas (2000) indicate that PBL promotes deeper learning by enabling students to apply their knowledge to solve real-world problems. Similarly, the Kolb (2014)'s experiential learning framework underscores the importance of learning through experience and reflection, which has been shown to enhance engagement and retention.

IBL, as articulated by Prince (2004) encourages students to take ownership of their learning by formulating questions and seeking solutions, thereby fostering independent learning and problem-solving capabilities.

The tearning model bridges these gaps by harmonising teaching and learning into a seamless cycle. By integrating pre-assessment, differentiated instruction, and project-based methodologies, tearning ensures that education is adaptive, responsive, and fundamentally student-centred.

Theoretical Framework

Constructivist Theory

The tearning model is fundamentally grounded in constructivist learning theory, concluding that students construct their understanding of concepts through experience, interaction, and reflection. Constructivism articulated by Piaget (1977) and Vygotsky (1978) emphasised that learning is an active process where students build new knowledge by integrating it with prior understanding. This model reflects the principle of student-centred learning, where the teacher shifts from a knowledge provider to a facilitator of learning, guiding students through hands-on projects, collaboration, and inquiry (Sungur & Tekkaya, 2006; Coulson & Harvey, 2013).

Differentiated Learning and Neuro-Linguistic Programming (NLP)

A vital component of the tearning model is its emphasis on differentiated learning, which accommodates the diverse learning needs of students. Recognising that students possess varied learning styles, abilities, and backgrounds, differentiated learning ensures that instruction is personalised to meet each student's unique needs(Wijnia et al., 2024).

NLP complements the tearning model by enhancing self-awareness and promoting autonomy in learning. NLP examines the connection between neurological processes, language, and behavioural patterns, and in an educational context, it can help students develop effective learning strategies, improve communication skills, and build confidence (Coulson & Harvey, 2013).

Pre- and Post-assessment

Pre-assessment is a diagnostic tool that allows teachers to gauge students' knowledge and skill levels before instruction begins. By identifying areas of proficiency and topics requiring additional focus, teachers can design lessons that are more targeted and responsive to class needs (Dixson & Worrell, 2016; Garrison & Ehringhaus, 2007; Harlen & James, 1997). Conversely, post-assessment evaluates student progress and determines whether learning objectives have been achieved.

Methodology

The study employs a quasi-experimental, mixed-methods design, integrating quantitative assessments and qualitative insights.

Table 1 Summary of mixed-methods design

Method	Data Type	Purpose
Pre-assessment	Quantitative	Measure baseline knowledge
Post-assessment	Quantitative	Evaluate learning progress
Surveys	Qualitative	Capture student perceptions and engagement levels
Classroom Observation	Qualitative	Document student participation and teacher interaction

Participants

The study involves 24 students enrolled in a PMP course in the Computer Science Department. The participants are divided into two groups: in-person and online students. The in-person students attend regular classes, participate in daily activities, and engage in pre-tests and discussions, while the online students face challenges due to limited participation.

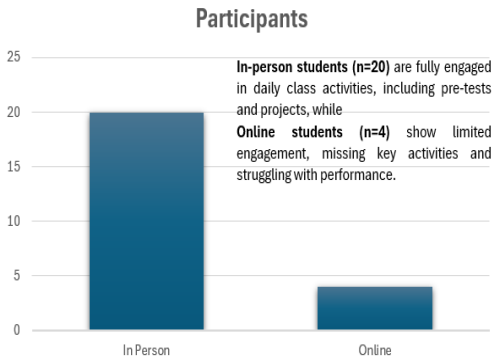


Figure 1 Breakdown of the participants

Data Collection

Quantitative Data

Table 2 How quantitative data was generated

Data Type	Details
Surveys	Purpose: Gather insights into student engagement, motivation, and perceptions of the learning experience. Timing: Mid-course and end-of-course. Format: Likert-scale items and open-ended questions.
Classroom Observations	Purpose: Document interaction between students and teachers. Method: Observations of classroom sessions. For Online Students: No specific learning tool was used to monitor participation and performance.

Table 3 Sample questions from the assessments

Question Type	Pre-Test Example	Post-Test Example
Multiple Choice	What is the primary goal of risk management?	Which tool is most suitable for stakeholder analysis?
Scenario-based	Identify risks in a provided project scenario	Propose risk mitigation strategies for a complex project
Open-ended	Describe the role of a project manager	Explain how resource allocation can affect project outcomes

Qualitative Data

Table 4 How qualitative data was generated

Qualitative Analysis Step	Details
Thematic Analysis	The qualitative data from surveys and interviews were analysed to identify themes related to engagement, student-teacher interaction, and perceived effectiveness of the learning model.
Coding	Survey responses and interview transcripts were coded to identify key themes such as autonomy, collaboration, and critical thinking.
Theme Identification	Common themes were identified, focusing on the challenges faced by online learners.
Triangulation	Findings from surveys, interviews, and observations were cross-referenced to validate the results.

Discussion

The tearning model enhances educational outcomes by integrating teaching and learning. Quantitative data showed improved critical thinking and problem-solving through project-based learning, while qualitative feedback highlighted increased student engagement in hands-on projects. However, online learners faced participation challenges that impacted their performance. Despite this, students appreciated the model's flexibility. Tearning promotes better outcomes in multi-disciplinary courses, fostering critical thinking and collaboration skills.

Conclusion

The tearning model effectively integrates teaching and learning, improving student engagement, critical thinking, and outcomes in multi-disciplinary courses like Project Management Professional (PMP). While in-person and online students benefited from project-based learning, online learners faced more significant participation challenges. Feedback highlighted that active engagement in hands-on projects is crucial for success. Students who participated in pre-tests and critical thinking exercises performed better in mid-semester assessments, demonstrating the value of active learning strategies.

References

Affandi, A., & Sukyadi, D. (2016). Project-based learning and problem-based learning for EFL students' writing achievement at the tertiary level. *Rangsit Journal of Educational Studies*, *3*(1), 23-40.

Barron, B., & Darling-Hammond, L. (2008). *Teaching for Meaningful Learning: A Review of Research on Inquiry-Based and Cooperative Learning.* George Lucas Educational Foundation.

Brookhart, S. M. (2010). How to Assess Higher-Order Thinking Skills in Your Classroom. Virginia: ASCD.Coulson, D., & Harvey, M. (2013). Scaffolding student reflection for experience-based learning: *A framework. Teaching in Higher Education, 18*(4), 401-413.

Dixson, D. D., & Worrell, F. C. (2016). Formative and summative assessment in the classroom. *Theory into Practice*, *55*(2), 153-159.

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem-and project-based learning. *Interdisciplinary Journal of Problem-Based Learning*, *7*(2), 6.

Freire, P. (1996). *Pedagogy of the Oppressed* (revised). New York: Continuum, 356, 357-358.

Garrison, C., & Ehringhaus, M. (2007). Formative and summative assessments in the classroom. *Theory and Practice, 55*(2):14 .Doi: 10.1080/00405841.2016.1148989

Hannafin, M. J., & Land, S. M. (2000). Technology and student-centered learning in higher education: Issues and practices. *Journal of Computing in Higher Education*, *12*, 3-30.

Harlen, W., & James, M. (1997). Assessment and learning: differences and relationships between formative and summative assessment. *Assessment in Education: Principles, Policy & Practice*, *4*(3), 365-379.

Kolb, D. A. (2014). *Experiential Learning: Experience as The Source of Learning and Development*. London: Pearson Education Limited:

Marlina, M., Kusumastuti, G., & Ediyanto, E. (2023). Differentiated Learning Assessment Model to Improve Involvement of Special Needs Students in Inclusive Schools. *International Journal of Instruction*, *16*(4), 432-440.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I—Outcome and process. *British Journal of Educational Psychology*, *46*(1), 4-11.

Piaget, J. (1977). *The development of thought: Equilibration of cognitive structures*. (Trans A. Rosin). Viking.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223-231.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54-67.

Sungur, S., & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. *The Journal of Educational Research, 99*(5), 307-320.

Thomas, J. W. (2000). A Review of Research on Project-Based Learning, San Rafael, CA: Autodesk Foundation.Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*, Harvard: Harvard University Press.

Wijnia, L., Noordzij, G., Arends, L. R., Rikers, R. M., & Loyens, S. M. (2024). The effects of problem-based, project-based, and case-based learning on students' motivation: A meta-analysis. *Educational Psychology Review*, *36*(1), 29.

Immersive Technology of VR is Revolutionising The Learning Experience for Applied Chemistry Students: Navigating Complex Operations of Wastewater Treatment Plant

Jun Wei Lim
Department of Fundamental and Applied Sciences, Universiti Teknologi PETRONAS, Malaysia
* junwei.lim@utp.edu.my

Introduction

During the COVID era, the inability to physically visit a wastewater treatment plant posed a significant obstacle to the Sustainable Water Management course offered to Applied Chemistry students. The hands-on experience of witnessing and understanding the complex operations of such facilities is crucial for these students, as it directly relates to their future roles in environmental stewardship and sustainable practices (Häfner et al., 2013). Recognising the importance of experiential learning, a virtual reality (VR) of immersive technology was instituted as a solution. The VR offered a compelling alternative, allowing students to immerse themselves in a simulated environment that closely mimicked the real-world setting of a wastewater treatment plant. This virtual experience replicated the visual and auditory aspects and allowed for interactive exploration and learning.

In this regard, the transition to VR has brought about several advantages that surpass the limitations of traditional physical visits. Unlike a single physical visit, VR allows for repeated and on-demand access to the virtual environment (Al Kork & Beyrouthy, 2018; Remolar et al.,2021). Students can revisit scenarios, explore operational challenges, and practice problem-solving in a safe and controlled environment. This iterative learning approach reinforces their understanding and facilitates deeper engagement and knowledge retention over time (Mariscal et al., 2020). Furthermore, integrating VR into the curriculum has alleviated logistical burdens and costs associated with physical field trips. It eliminates the need for coordinating transportation, navigating scheduling conflicts, and ensuring site availability, which can be significant barriers in traditional education settings. By embracing VR, educational institutions can also redirect resources towards enhancing the quality of learning materials and supporting students' comprehension through innovative technology. The adoption of VR in Sustainable Water Management courses for Applied Chemistry students has proven to be transformative (Kavanagh et al., 2017). It not only overcomes the challenges posed by the Covid era but also enhances the overall educational experience by offering a dynamic and accessible platform for learning. Moreover, by leveraging VR immersive technology, educators can effectively prepare students to tackle real-world challenges in wastewater treatment operations. Thus, it fulfils the course's objectives of equipping future professionals with essential knowledge and skills in environmental sustainability.

Methodology

The VR experience described was meticulously crafted to simulate the journey of wastewater treatment through an activated sludge process, culminating in its release as effluent into a

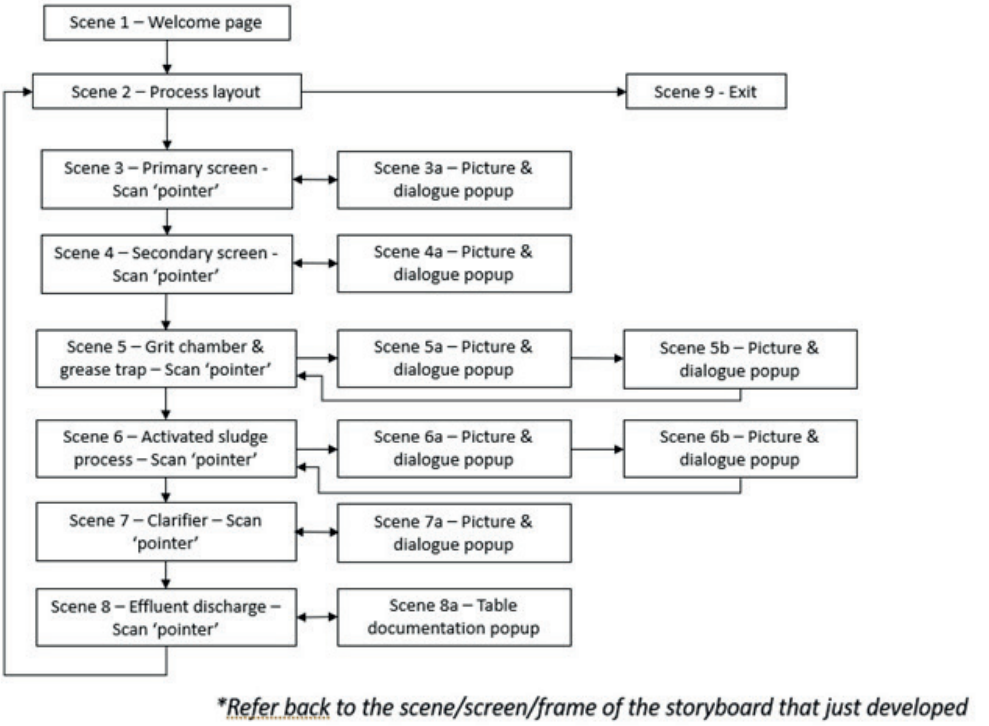


Figure 1 The VR Storyboard of wastewater treatment plant employing activated sludge process

natural water body (Kavanagh et al., 2107). The VR development began with careful planning to replicate the influent wastewater flow through each operational mode of the activated sludge process. Indeed, this process is crucial in wastewater treatment plants to effectively remove contaminants. In creating an immersive experience, the 3D images of each operational mode were captured using a high-tech 3D camera provided by CAdEx, UTP. These images serve as the visual backbone of the VR simulation, ensuring accuracy and realism in depicting each stage of the treatment process. Thereafter, descriptive elements and visual representations were integrated into the VR environment. Each operational mode was accompanied by concise descriptions that explain its purpose, function, and significance within the activated sludge process. This educational aspect enhances the learning experience by providing context and understanding to the students learning about wastewater treatment. Finally, the programming for VR navigation was developed to enable seamless simulation through the different operational modes. The storyboard for VR in programming is as shown in Figure 1. Students can systematically explore each stage of the treatment process, guided by the integrated descriptions that clarify the operations taking place.

In terms of educational value, the primary goal of this VR experience is for educational purposes. By immersing students in a virtual environment that replicates real-world processes, they can gain a deeper comprehension of how wastewater is treated through the activated sludge process. This hands-on approach fosters better understanding and retention of complex concepts as opposed to traditional learning methods (Aal Kork & Beyrouthy, 2018) Overall, this VR project not only showcases technological innovation but also leverages immersive storytelling and educational





Figure 2 The left image shows the VR simulation mode and the right image presents the VR setup

techniques to convey the complexities of wastewater treatment plants (Figure 2). It transforms abstract theories into tangible experiences, making the learning process more engaging and effective for students studying the Sustainable Water Management course or related fields.

Results and Discussion

After the virtual reality (VR) set is ready, the Applied Chemistry students are allowed to explore the simulation in a wastewater treatment plant employing an activated sludge process. In fact, experiential learning via VR mode is incorporated into blended learning activities. The performances of students in comprehending the wastewater treatment plant

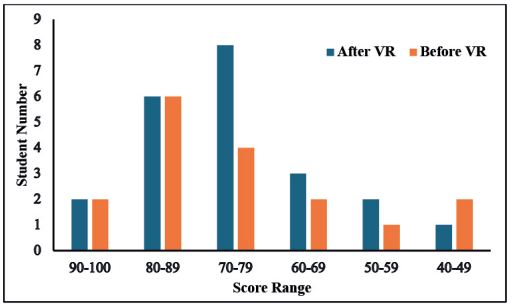
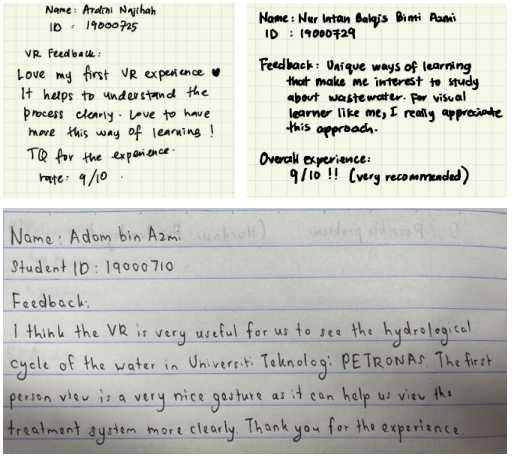


Figure 3 Performances of students in comprehending the operations of wastewater treatment plant by comparing the groups before and after the VR set was developed

were compared between the groups before and after using the VR set, namely, semesters before and after the VR set was developed, respectively. The outcomes are shown in Figure 3, demonstrating that the adoption of VR in teaching and learning activities did improve the student's academic performances, with more students scoring in the 70-79 range. In this regard, it could be concluded that the VR application could offer a better understanding towards the complex operations of wastewater treatment plants employing activated sludge process with students' feedback, as shown in Figure 4. Activated sludge refers to the mixed microbial communities that collectively and symbiotically remove pollutants in wastewater to satisfy the discharge standard's requirement.



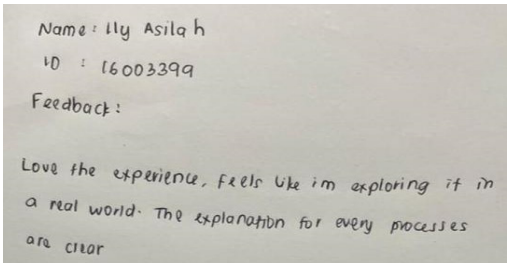


Figure 4 CFeedback from students after the VR session

Conclusion

Integrating VR learning mode into the Applied Chemistry program, particularly the Sustainable Water Management course, has proven transformative. By immersing students in a VR simulation of the activated sludge process, the learning became experiential and engaging. Comparative assessments before and after VR implementation highlighted improved student academic performances, validating VR's role in enhancing comprehension of complex wastewater treatment operations. The VR's depiction of activated sludge, where microbial communities synergistically purify wastewater, reinforced an understanding of environmental principles. This technology enriches educational experiences and equips students with practical knowledge essential for addressing real-world challenges in wastewater management.

References

Al Kork, S., & Beyrouthy, T. (2018). Interactive virtual reality educational application. *Adv. Sci. Technol. Eng. Syst. J.*, *3*, 72–82.

Häfner, P., Häfner, V., & Ovtcharova, J. (2013). Teaching methodology for virtual reality practical course in engineering education. *Procedia Comput. Sci.*, *25*, 251–260.

Kavanagh, S., Luxton-Reilly, A., Wuensche, B.C., & Plimmer, B. A. (2017). Systematic review of Virtual Reality in education. *Themes Sci. Technol. Educ*.

Mariscal, G., Jiménez-García, E., Vivas, M.D., Redondo, S., & Moreno-Pérez, S. (2020). Education in the Knowledge Society Virtual Reality Simulation-Based Learning. *Educ. Knowl. Soc. (EKS)*, *21*, 15.

Remolar, I., Rebollo, C., & Fernández-Moyano, J.A. (2021). Learning History Using Virtual and Augmented Reality. *Computers*, 10, 146.

Designing A Computer Networks Course with Active Learning and Gamification Approach

Junaid Shuja[1], Muhammad Ali Humayun[2], Abdullateef Oluwagbemiga Balogun[1*], Mohd Hilmi Hasan[1]
[1]Universiti Teknologi PETRONAS, Malaysia
[2]Information Technology University, Pakistan
*abdullateef.ob@utp.edu.my

Introduction

Computer science, information technology (IT), and software engineering education have risen in recent decades. The trend is fueled by integrating computing and information technology in socio-economic sectors such as healthcare, transportation, business, finance, and agriculture. The curriculum of computing and IT has several core courses, including computer networks, taught in universities and institutes of higher learning across the globe. Like other computing and IT courses, computer networks can be covered in depth and breadth with topics ranging from TCP/IP model to wireless networks and security (Ameen et al., 2017; Prvan & Ožegović, 2020; Sasi et al., 2020).

The debate on learning pedagogy has re-emerged since COVID-19 as the learning space transitioned to online and virtual environments. Moreover, generation Z has been brought up with technology, intelligent tools, and high-speed internet access. Massive open online courses (MOOCs) are often freely available where students can easily engage in distance and asynchronous learning. Therefore, synchronous and on-campus learning needs reinvention to engage students highly in the learning environment. Academics have realised that the future of education can be a hybrid classroom where different teaching methods are required for effective content delivery (Ahmed & Opoku, 2022; Shuja et al., 2021).

This context advocates a student-centric active learning and gamification approach to teaching science and engineering courses. Active learning demands the lecturer to prepare a book-end approach to engage students in small sessions and topics while positioning student-centred activities between the course content and issues. Cooperative learning (CL) is an active learning technique proven to be highly effective as it engages students in teams to focus on the course. Informal cooperative learning techniques such as brainstorming and think-pair sharing can be applied to engage students (Hamadi et al., 2022). Informal cooperative learning techniques help students engage and concentrate in the learning environment.

The higher student participation means that there is even less time for deep content coverage, considering the details of the TCP/IP model. The breadth and depth of computer network courses demand that topics be selected while prioritising outcome-based education (OBE). OBE advocates an educational approach focusing on well-planned outcomes, goals, and skills (Shen, 2020). Professionals and academics in computer networks can be engaged in surveying the relevance of course topics in OBE. The prioritised topics can then be planned using an active learning book-end-based approach for a student-centric approach.

The contributions of this article are as follows.

1. We conduct a survey to prioritise computer network topics based on outcome-based education.

2. We develop active learning and gamification-based lecture and laboratory outline for the prioritised topics of computer networks.

The rest of the article is structured as follows: first, a discussion on related works is presented. Next, the active learning approach is explored, followed by an outline of computer networks. The gamification approach for the course is then introduced, highlighting its benefits. Subsequently, the survey details are examined to prioritise course content in alignment with OBE principles. Finally, the article concludes with key remarks and insights.

Active Learning and Gamification

We list a 12-week semester course outline for computer networks in Table 1. The lecture is two hours long each week. The lecture session is designed based on the Book-ends division. The session starts with an advanced organiser and follows with five 15-minute smaller sessions on sub-topics to be taught. A five-minute activity, demo, or game is added between every two smaller sessions, leading to at least four activities in each lecture. The lecture is ended with a 5-minute summary. Informal five breaks can be added at one hour time to improve student concentration.

The lecture contents follow the top-down approach advocated in (Kurose, 2005). The learning activities are based on cooperative learning, which has been proven to be effective in science and engineering studies (Helmi et al., 2017). Table 2 presents the corresponding week-wise lab content for the course. Gamification has been proven technique to increase student engagement and participation in the classroom (Patil & Kumbhar, 2021).

Table 1 Week-wise lecture plan

Week	Topics	Activities
W1	Computer Networks and the Internet	
	The nuts and bolt view	Activity: Opening Question: How well you know your network
	What is protocol?	Activity: Brainstorming: Know your network with IP-CONFIG
	What is the Internet and its Structure?	Activity: Form think-pair-share teams for rest of the semester
	Access Network	Activity: Think pair Share: What is difference between network and Internet
	Physical layer overview	
W2	Computer Networks and the Internet	Game (MCQ): https://gaia.cs.umass.edu/kurose ross/knowledgechecks/
	Internet Core	Demo: Understand IP configurations
	Packet switching	Activity: Pair testing: Calculate delay of a network
	Performance: Delay	Activity: Think pair share: Find human analogies for layered service model
	Layered Architecture: TCP/IP	

cont... **Table 1**

Week	Topics	Activities
W3	Application Layer	Activity: Think pair share: client server advantages
	Network Applications,	Demo: Download and Install Wireshark
	Application model	Demo: Basic GUI of wireshark
	Client-server applications	Game (MCQ): Author online resources
	Sockets	
	HTTP Overview	
W4	Application Layer	Activity: Think pair share: Internet vs web
	HTTP Format	Activity: Capture HTTP in wireshark
	HTTP Methods	Demo: POST method in browser
	Cookies	Game (MCQ): Knowledge check
	Proxy server	Coding: Demo UDP sockets in Python
	HTTP2	Take Home Reading: P2P applications
W5	Application Layer	Active: Opening Question: P2P
	DNS	Demo: DNS records on system
	DNS Server	Activity: Note Checking: DNS server hierarchy
	DNS records	Demo: Interactive DNS queries (https://tinyurl.com/2khnha25)
	DNS format	Take Home Reading: Email/ SMTP application
	Video Streaming and CDN	Assignment: Socket Programming
W6	The Transport Layer	
	Transport-Layer Services	Activity: Focused Listing: Why we need connectionless service?
	Multiplexing-demultiplexing	Game (MCQ): Knowledge check
	UDP	Demo: UDP Socket in Python
	UDP format	Activity: Closure review pairs: Connection vs connection-less transport
	UDP checksum	
W7	The Transport Layer	
	Principles of RDT	Activity: Opening Question: Why do we need reliable transport?
	Stop-and wait protocols	Activity: Think pair share: Human analogies of reliable transport
	Pipelined protocols	Game (MCQ): Knowledge check
	Go-back-N	Demo: Install packet tracer
	Selective Repeat	Further watching: https://www.youtube.com/watch?v=nyUHUtmxWg0

cont... **Table 1**

Week	Topics	Activities
W8	The Transport Layer	
	TCP	Activity: Brainstorm: Which applications will use TCP?
	TCP timeout	Game (MCQ): Knowledge check
	Flow control	Demo: Animation of congestion control (https://tinyurl.com/mvszhxz2)
	Connection management	Activity: Reflection: Difference between Flow and congestion control
	Principles of congestion control	
W9	The Transport Layer	
	TCP Congestion Control	Activity: Pair composition: Implicit vs explicit CC
	TCP Tahoe vs Reno	Game (MCQ): Knowledge check
	The Network Layer	Take home Reading. TCP Cubic
	Data vs Control Plane	Activity: Think pair share: Routing vs forwarding
	What is inside router	Demo: Tracecert + how to calculate RTT
W10	The Network Layer	
	Longest Prefix match	Activity: Opening Question: Data vs control plane
	IPv4	Game (MCQ): Knowledge check
	Subnets	Activity: Think Pair Share: Examples of LPM
	CIDR	Demo: DHP in wireshark
	DHCP	Take home reading: Class based addressing
W11	The Network Layer	
	Route aggregation	Activity: Question and answer pair: DHCP
	NAT	Game (MCQ): Knowledge check
	IPv6	Demo: Show route table on system
	Overview of control plane	Activity: Brainstorm: Human analogies for routing and forwarding
	OpenFlow	
W12	The Network Layer	
	Link state routing	Activity: Think pair share: pros of DV vs LS
	Distance vector routing	Demo: Show CMD-MAC address format
	The Link Layer	Demo: ARP table in system
	MAC	Activity: Closure question: Advantages of CL/AL
	ARP	
	A day in the life of a web request	

Table 2 Week-wise lab plan

Week	Topic	Tools	Tasks
W3	HTTP	Wireshark	Analysis of HTTP messages including caching using Wireshark
W4	DNS	Wireshark	Analysis of DNS query response messages using Wireshark
W5	TCP	Wireshark	Analysis of TCP connection setup and data stream for file transfer
W6	UDP Multiplexing	Python Socket Programming	Implement a UDP client server application in pairs
W7	TCP Multiplexing	Python Socket Programming	Implement a TCP based client server application for file transfer
W8	IP Subnetting	GNS3 Simulator	Design and implement IP subnet scheme for a network topology inGNS3
W9	Static Routing	GNS3 Simulator	Design and configure static routing for a network topology in GNS3
W10	OSPF	GNS3 Simulator	Configure OSPF routing for a network topology and manipulate linkcosts to modify traffic paths
W11	BGP	GNS3 Simulator	Configure BGP for inter-AS routing in a network topology andmanipulate BGP attributes to modify traffic paths
W12	Ethernet	GNS3 Simulator	Configure Ethernet switch with VLANS to breakdown broadcastdomains

Students are introduced to the approach at the start of the course. The game is played in most of the lectures, where students can earn game points by,

1. Participating in quizzes questioning their knowledge and understanding of the lecture contents. The quiz is often a multiple-choice question based on the knowledge checks of the book's online resource centre,
2. Asking a relevant question from the instructor
3. Answering a question from the instructor. Based on correct answers and participation, students earn game points, which can be recorded at the end of the lecture.

The game points can be converted into bonus marks for the students, compensating them for their mistakes in other assessments. The game points can also be used to distribute certificates and tokens of appreciation among the students (Gamarra et al., 2022). The gamification approach increases student motivation for participation. Often, introverted students participate in classroom activities and concentrate on the lecture delivery in anticipation of game points. Moreover, the instructor can focus the game questions on a group of students who participate less in the classroom (Milosz & Milosz, 2020). The online author and student resources can be utilised for gamification.

Outcome Based Education

The course content for computer networks and communication is vast, with academics mostly following a top-down approach to teaching the TCP/IP model. As the course content cannot be

covered in a semester, it is important to identify the depth and breadth of topics to cover. The best method to prioritise the topics is with the help of OBE. It emphasises adopting an educational approach that leads to specified outcomes, goals, and skills for the students (Liu et al., 2024).

The OBE defines course learning outcomes (CLO) for each course. The CLO vary based on instructor and university teaching methods. In the case of computer networks, the general CLO gathered from author universities is listed in Table 3.

Research Methodology

We surveyed to identify computer networks course content that is more relevant considering outcomes and skills. The survey participants were academics, practitioners, and technologists in computer networks and communication. The survey presented the course content adapted from the top-down approach (Kurose, 2005). The participants were asked to submit a rating of 1-5 for low to high relevancy regarding skills and outcomes. Ten responses were collected. The survey topics and their average score are listed in Table 4.

Table 3 CLO from author universities

CLO	University 1	University 2
CLO1	Apply the knowledge in data communications and networking in the context of LAN and WAN	Apply the concepts of computer networks to solve its related problems
CLO2	Design and build small to medium size network infrastructure using common networking devices	Analyse various protocols, algorithms, and their functions in a network
CLO3	Propose enhancement for current networking infrastructure and measure its improvement	Comprehend the fundamentals of wireless and mobile networks along with the security issues

Table 4 Analyses of survey responses

Topic Sequence	Topic Name	Average Score	Score Variance
1	Basic Internet Architecture	4.3	0.9
2	Delay, Loss, and Throughput in Packet-Switched Networks	4.2	1.1
3	Protocol Layers and Their Service Models	4.8	0.2
4	Principles of Network Applications	3.4	1.2
5	The Web and HTTP	3.8	1.1
6	Electronic Mail in the Internet	3.1	1.4
7	DNS—The Internet's Directory Service	4.5	0.5
8	Peer-to-Peer File Distribution	3.7	0.5
9	Video Streaming and Content Distribution Networks	3.7	1.5
10	Socket Programming: Creating Network Applications	4.2	0.8
11	Introduction to Transport-Layer Services	4.4	0.5
12	Process Multiplexing and Demultiplexing	3.8	1.3
13	Connectionless Transport: UDP	4.4	0.9

cont... **Table 4**

Topic Sequence	Topic Name	Average Score	Score Variance
14	Principles of Reliable Data Transfer	3.9	0.8
15	Connection-Oriented Transport: TCP	4.5	0.7
16	Principles of Congestion Control	3.8	1.1
17	TCP Congestion Control	4.4	0.5
18	Evolution of Transport-Layer Functionality	3.5	1.2
19	Overview of Network Layer	4.6	0.5
20	What's Inside a Router?	4	0.7
21	The Internet Protocol (IP): IPv4, Addressing	4.8	0.2
22	IPv6	4.2	0.6
23	Generalised Forwarding and SDN	3.8	0.8
24	Routing Algorithms	4.2	0.8
25	Intra-AS Routing in the Internet: OSPF	4.3	0.9
26	Routing Among the ISPs: BGP	4.2	0.6
27	The SDN Control Plane	3.9	0.5
28	ICMP: The Internet Control Message Protocol	3.9	0.5
29	Network Management and SNMP	3.4	1.4
30	Introduction to the Link Layer	4.2	0.8
31	Error-Detection and -Correction Techniques	4	0.7
32	Multiple Access Links and Protocols	3.7	0.9
33	Switched Local Area Networks	4	0.9
34	Link Virtualisation: A Network as a Link Layer	3	0.9
35	Data Center Networking	3.3	0.5

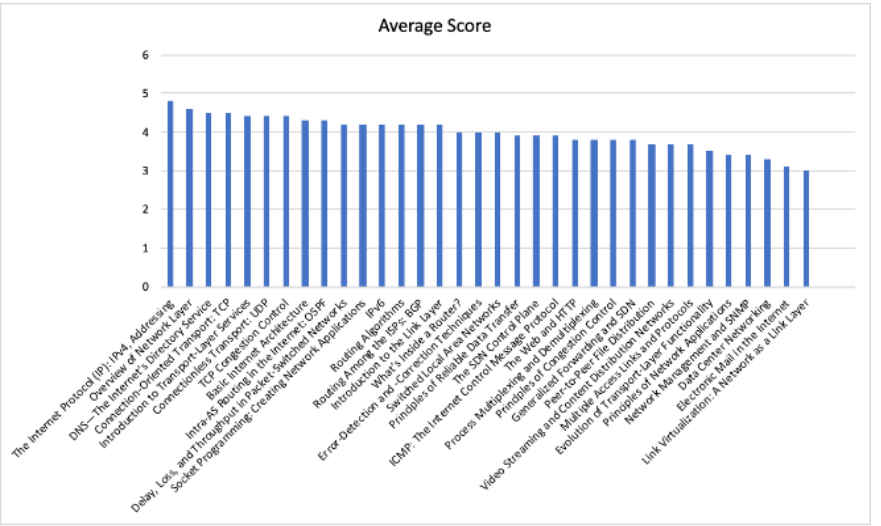


Figure 1 Pictorial representation of the average score of respondents from the survey

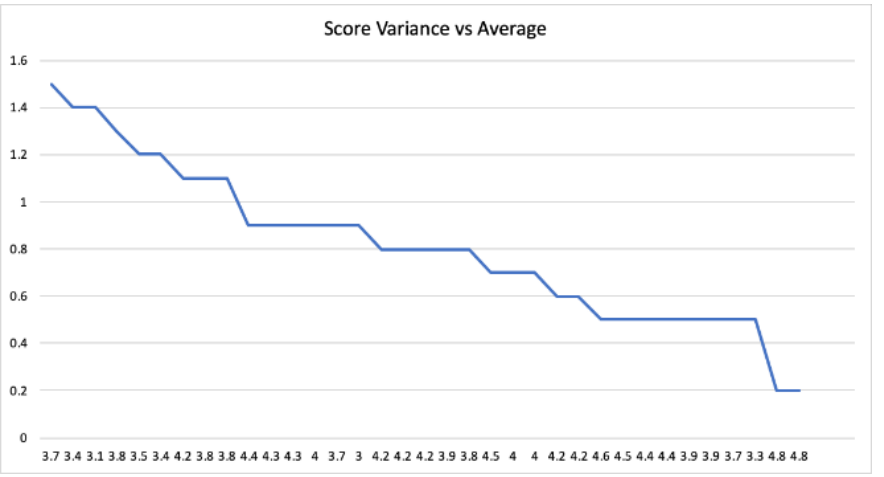


Figure 2 Pictorial representation of the correlation between the average score and the score variance from the survey

As presented in Figure 1, the average score shows that the respondents gave higher ratings to topics including DNS, IPv4, addressing, and network layer. However, topics including link-layer virtualisation, electronic mail (SMTP), and data center networking have lower ratings.

Further analysis of the score variance and average score, as represented in Figure 2, shows that the highly rated topics have low variance among the responses. This signifies that most respondents rated the same topics highly important concerning OBE.

Conclusion

The article's objective was to identify methods for effective delivery of learning outcomes for computer network courses. The identified methods, such as active learning and gamification, depend on classroom constraints that may hinder complete compliance. The constraints are the classroom size, available time, and student diversity. However, the course can be designed based on the topic priorities identified in this article.

References

Ahmed, V., & Opoku, A. (2022). Technology supported learning and pedagogy in times of crisis: The case of COVID-19 pandemic. *Education and Information Technologies*, *27*(1), 365-405.

Ameen, A. O., Olatinwo, D., Alamu, F., Olatinwo, S., & Balogun, A. O. (2017). Design and Analysis of Network Models for QoS Routers on UDP and CBR. *Computer Science & Telecommunications*, *51*(1), 76.

Gamarra, M., Dominguez, A., Velazquez, J., & Páez, H. (2022). A gamification strategy in engineering education: A case study on motivation and engagement. *Computer Applications in Engineering Education*, *30*(2), 472-482.

Hamadi, M., El-Den, J., Azam, S., & Sriratanaviriyakul, N. (2022). Integrating social media as a cooperative learning tool in higher education classrooms: An empirical study. *Journal of King Saud University-Computer and Information Sciences*, *34*(6), 3722-3731.

Helmi, S. A., El Hassani, S., Yusof, K. M., & Phang, F. A. (2017). Enrichment of problem-solving skills among engineering students through cooperative problem-based learning. *2017 7th World Engineering Education Forum (WEEF)*, 13-16 November, Kuala Lumpur.

Kurose, J. F. (2005). *Computer networking: A top-down approach. , Third Edition, Chennai: Pearson Education India.*

Liu, T., Yang, W., Shang, H., & Jia, J. (2024). Teaching Reform and Practice of Computer Networking Courses Based on the OBE Concept. *International Journal of New Developments in Education, 2024, 6*(6); Doi: 10.25236/IJNDE.2024.060614.

Milosz, M., & Milosz, E. (2020). Gamification in engineering education–a preliminary literature review. *2020 IEEE Global Engineering Education Conference (EDUCON)*, 27-30 April, Porto, Portugal.

Patil, Y., & Kumbhar, P. (2021). Learning by gamification: An effective active learning tool in engineering education. *Journal of Engineering Education Transformations, 34*, 447-453.

Prvan, M., & Ožegović, J. (2020). Methods in teaching computer networks: a literature review. *ACM Transactions on Computing Education (TOCE)*, *20*(3), 1-35.

Sasi, G., Thanapal, P., Balaji, V., Babu, G. V., & Elamaran, V. (2020). A handy approach for teaching and learning computer networks using Wireshark. *2020 Fourth International Conference on Inventive Systems and Control (ICISC)*, 8-10 January, Coimbatore, India.

Shen, G. (2020). Research on Online and Offline Mixed Teaching Based on OBE Concept: Taking the "Computer Network Fundamentals" course as an example. 2020 *International Conference on Modern Education and Information Management (ICMEIM)*, 25-27 September, Dalian, China.

Shuja, J., Humayun, M. A., & Rehman, M. H. U. (2021). Innovating educational policies with machine learning in the COVID-19 pandemic. *2021 Machine Learning-Driven Digital Technologies for Educational Innovation Workshop*, 15-17 December, Monterrey, Mexico.

Enhancing Clinical Learning with Artificial Intelligence: Improving Creativity and Critical Thinking Through AI-Generated Clinical Case Studies

Zaswiza Mohamad Noor
Universiti Kuala Lumpur Royal College of Medicine, Malaysia
*zaswiza@unikl.edu.my

Introduction

Artificial intelligence (AI) is increasingly utilised across various fields, including education and healthcare (Topol, 2019; Luckin et al., 2016). In clinical pharmacy, AI can be pivotal in developing realistic and challenging case studies that mirror real-world scenarios. This study examined the effectiveness of using ChatGPT to generate case studies that enhance students' analytical and collaborative skills. By engaging with AI-generated cases, students could practice identifying pharmaceutical care issues (PCI), formulating accurate diagnoses, and recommending appropriate interventions. The primary objectives were to,

1. Utilise AI to develop clinical case studies for clinical discussions.
2. Enhance students' ability to identify and rectify PCI within the case studies.
3. Improve students' critical thinking and problem-solving skills through in-depth class discussions.
4. Foster communication among students through group presentations and peer feedback.

Literature Review

Recent studies highlighted the use of ChatGPT in medical education. Leelavathi and Surendhranatha (2024) emphasised its role in enhancing student engagement and critical thinking through interactive, personalised learning. Wu et al. (2024) further underscored ChatGPT's ability to improve clinical reasoning and decision-making, which is essential in case-based learning. Wong et al. (2024) asserted its effectiveness in helping students understand complex clinical cases and develop healthcare communication skills. These findings suggested that AI integration could significantly enhance critical thinking and problem-solving, mirroring real-world clinical practice.

Methodology

In the Clinical Therapeutics (CT) course, Year-4 Pharmacy students were divided into eight groups (N=8), with psychiatric disorders (n=4) and neurologic disorders (n=4), respectively. Each group used ChatGPT to generate a detailed case study. The case studies included diseases/disorders, complaints and symptoms, medical history, medications, laboratory test results, and PCI, i.e., potential problems related to the patient's medications and treatment plan. These components were intricately associated with the cases, providing a realistic and comprehensive framework (McLean, 2016). The case studies might contain some inaccuracies, challenging students to identify and rectify the errors by comparing them with the standard guidelines

and clinical references. Additionally, each group formulated five discussion questions related to their case to facilitate a more profound analysis. The methodology involved several steps, as shown in Figure 1.

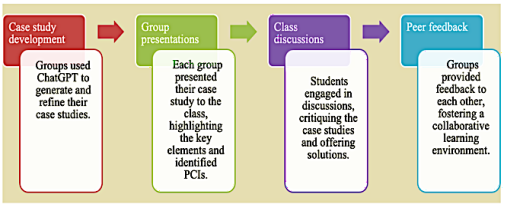


Figure 1 The process of developing case studies

Results and Discussions

The findings highlighted varying levels of analytical and problem-solving skills among students.

Identification and Rectification of Issues

Two groups successfully identified and rectified PCIs in their cases. One group dealing with major depressive disorder (MDD) and obsessive-compulsive disorder (OCD) demonstrated strong competence, accurately identifying issues and providing reliable recommendations. One group focusing on multiple sclerosis, a neurologic disorder, excelled in identifying problems and offering appropriate interventions.

Challenges Faced by Students

The other six groups struggled to identify and rectify the issues in their case studies. These groups often missed key inaccuracies to provide appropriate recommendations. However, these challenges presented valuable learning opportunities, leading to further discussions and deeper analysis.

Peer Involvement

Groups received assistance from classmates, enhancing collaboration and overall class engagement. This collaborative environment contributed to a better learning experience.

Development of Professional Communication Skills

The presentations and discussions provided a platform for students to practice and improve their communication skills. Students gained confidence and proficiency in professional communication by articulating thoughts, critiquing their peers, and defending their recommendations.

The use of ChatGPT to develop clinical case studies could be an effective educational tool. The AI-generated scenarios offered realistic and challenging contexts, encouraging students to engage deeply with the material. Deliberate inaccuracies in case studies catalysed critical thinking, prompting students to apply theoretical knowledge to practical situations. The varied understanding reflected differing student competencies, as expected in any educational setting. Nonetheless, the exercise's collaborative nature facilitated peer learning, ensuring that all students benefited from the activity. The structured format of the case studies, including patient histories, medication lists, and lab results, closely mirrored real-world clinical scenarios, making the learning experience both relevant and practical. The requirement to formulate discussion questions further deepened student engagement and promoted critical thinking.

Conclusion

In conclusion, using ChatGPT to create case studies for a Clinical Therapeutics course offers substantial benefits by enhancing

students' critical thinking, problem-solving, collaboration, and communication skills. The AI-generated scenarios simulate real-world clinical situations, preparing students for future healthcare roles. Despite some challenges, the study demonstrates AI's potential as a valuable tool in Pharmacy education. Future research could explore the long-term effects of this approach on clinical competencies and its application in other medical education areas.

References

Luckin, R., Holmes, W., Griffiths, M. & Forcier, L.B. (2016). *Intelligence Unleashed: An Argument for AI in Education*. London: Pearson.

Leelavathi, R. & Surendharanatha, R.C. (2024). ChatGPT in the classroom: navigating the generative AI wave in management education. *Journal of Research in Innovative Teaching and Learning*, 2397-7604. Doi: 10.1108/JRIT-01-2024-0017.

McLean, S.F. (2016). Case-based learning and its application in medical and healthcare fields: A review of worldwide literature. *Journal of Medical Education and Curriculum Development*, 3, Doi: 10.4137/JMECD.S20377.

Topol, E.J. (2019). High-performance medicine: The convergence of human and artificial intelligence. *Nature Medicine, 25*, 44–56.

Wong, K, Fayngersh, A, Traba, C, Cennimo, D, Kothari, N & Chen, S. (2024). Using ChatGPT in the development of clinical reasoning cases: A qualitative study. *Cureus*, *16*(5), e61438.

Wu,Y, Zheng, Y, Feng, B, Yang, Y, Kang, K & Zhao, A. (2024). Embracing ChatGPT for medical education: exploring its impact on doctors and medical students. *JMIR Med Educ, 10*, e52483.

Assessing The Impact of Blended Learning on First-Year Chemical Engineering Students

Man Kee Lam*, Thiam Leng Chew, Yee Ho Chai
Universiti Teknologi PETRONAS, Malaysia
*lam.mankee@utp.edu.my

Introduction

Blended learning, an educational approach that combines traditional face-to-face instruction with online learning components, has gained significant traction in higher education over the past decade. This method offers a flexible learning environment where students can access materials conveniently, often leading to increased engagement and improved learning outcomes (Garrison & Kanuka, 2004; Graham, 2006). Blended learning leverages the strengths of both in-person and online modalities, creating a more dynamic and interactive learning experience. In engineering education, where complex problem-solving and theoretical understanding are paramount, blended learning can enhance student comprehension and retention of complex concepts. Previous studies have shown that blended learning can lead to better academic performance and higher student satisfaction levels than traditional teaching methods (Lim & Morris, 2009; Chen & Jones, 2007). However, the effectiveness of this approach can vary depending on the course content, the level of student engagement, and the specific technologies used (Means et al., 2013).

The "Principles of Chemical Engineering" course at Universiti Teknologi PETRONAS is the first core course for first-year Chemical Engineering students, introducing them to essential concepts such as mass and energy balances. Historically, this course has been challenging for students, often resulting in high failure rates, particularly among those who struggle with the foundational calculations and theoretical concepts. A blended learning approach was introduced to address these challenges during the May 2023 semester. This intervention aimed to support students' understanding by providing interactive online content that could be accessed during their self-study periods. Incorporating elements such as YouTube videos, recorded lectures, and interactive assessments, the blended learning model was designed to reinforce key concepts and offer students a more flexible way to engage with the course material.

This study seeks to assess the impact of this blended learning intervention on student performance, mainly focusing on whether it helped improve the outcomes for students who had previously struggled with the course. by examining the changes in student performance before and after the introduction of blended learning, this research contributes to the growing body of literature on effective teaching strategies in engineering education.

Research Methodology

This study employed a mixed-methods approach to evaluate the impact of blended learning on the academic performance of first-year chemical engineering students in the "principles of chemical engineering" course.

Participants

The study involved 26 first-year chemical engineering students enrolled in the course during the May 2023 semester. These students had varying levels of academic performance, providing a representative sample for assessing the effects of the blended learning intervention.

Blended Learning Intervention

The blended learning approach was introduced for approximately three weeks, though not continuously, and included the following components,

1. Interactive content via H5P in uLearn: students were provided with YouTube videos, short recorded lectures explaining key theories related to mass and energy balances, and interactive assessments designed to reinforce their understanding.
2. Timing of intervention: the blended learning content was introduced after students had completed Quiz 1, Quiz 2, Quiz 3, and Test 1, where the average score was 76.20. the intervention aimed to address gaps in understanding before subsequent assessments.

Data Collection

Data were collected through the following methods:

1. Academic performance: student scores from Quiz 4, Quiz 5, Test 2, and a project were compared with their earlier performance. Additionally, the final exam scores were analyzed to assess overall course outcomes.
2. Qualitative feedback: informal feedback was gathered from students through discussions and observations, focusing on their experiences with the blended learning materials and their perceptions of its impact on their learning.

Data Analysis

Quantitative data were analyzed using descriptive statistics to compare pre- and post-intervention scores. Qualitative data were thematically analyzed to identify everyday experiences and challenges associated with the blended learning approach.

Result and Discussions

Academic Performance

As shown in Figure 1, following the introduction of blended learning, the average scores for Quiz 4, Quiz 5, Test 2, and the project rose to 79.4 from 76.2, indicating a modest improvement in student performance. This improvement was particularly notable among students initially struggling with the course content. These students showed significant gains in their scores, suggesting that the interactive and self-paced nature of blended learning helped them better understand the material.

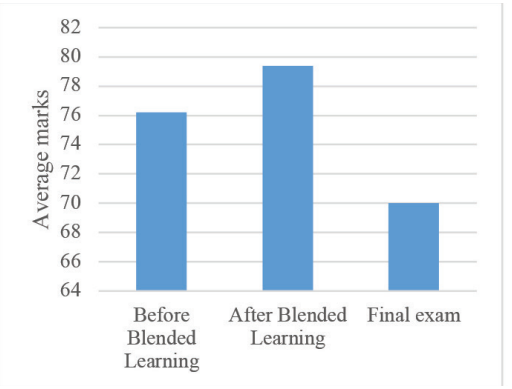


Figure 1 Average marks of students for blended learning approach

However, despite the positive trend in ongoing assessments, the average score for the final exam decreased slightly to 70. This drop may reflect the cumulative difficulty of the final exam or the challenges students faced in integrating

the various concepts covered throughout the course. Nevertheless, no students failed the final exam is a positive outcome, given the course's historical tendency to result in high failure rates.

Student Feedback

Students reported that the blended learning materials helped clarify complex concepts, particularly the recorded lectures and interactive assessments. Reviewing content at their own pace was cited as a significant advantage, allowing students to revisit challenging topics multiple times. However, some students mentioned difficulties in staying motivated and managing their time effectively without the structure of regular in-person classes. The qualitative feedback suggests that while blended learning provided valuable support, it also highlighted the need for strong self-regulation skills among students. For future course iterations, incorporating more structured guidance on time management and study strategies could further enhance the effectiveness of blended learning.

Conclusion

The introduction of blended learning in the "Principles of Chemical Engineering" course positively impacted student performance, particularly for those who had previously struggled. The increase in average scores for ongoing assessments indicates that the interactive and flexible nature of blended learning can effectively support student learning in challenging engineering courses. However, the slight decrease in the final exam average suggests that additional support may be needed to sustain these improvements through to the final assessment. Despite this, the overall pass rate improved, with no students failing the course, underscoring the potential of blended learning to reduce failure rates and support diverse learning needs. This study contributes to the growing evidence that blended learning can be a valuable tool in engineering education. Future research should explore the long-term effects of blended learning interventions and investigate strategies to optimize their implementation, particularly in courses with high difficulty levels.

References

Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, *7*(2), 95-105.

Graham, C. R. (2006). Blended learning systems: Definition, current trends, and future directions. In Bonk, C.J. & Graham C.R. (ed), *Handbook of Blended Learning: Global Perspectives, Local Designs*, (pp. 3-21), New Jersey: John Wiley & Sons.

Lim, D. H., & Morris, M. L. (2009). Learner and instructional factors influencing learning outcomes within a blended learning environment. *Educational Technology & Society*, *12*(4), 282-293.

Chen, C. C., & Jones, K. T. (2007). Blended learning vs. traditional classroom settings: Assessing effectiveness and student perceptions in an MBA accounting course. *Journal of Educators Online*, *4*(1), 1-15.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2013). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. *Teachers College Record*, *115*(3), 1-47.

Augmented Reality Application of Gas Turbine to Enhance Skills and Learning Experience for Trainees

Muhamad Syakirin Abdul Khalid[1*], Noreen Izza Arshad[1], Nur Irdina Nadira Mohd Dzahir[1], Mohamed Imran Mohamed Ariff [2]
[1]Universiti Teknologi PETRONAS, Malaysia.
[2]Universiti Teknologi MARA Cawangan Perak, Malaysia
[*]muhamad_20000635@utp.edu.my

Introduction

Gas turbine training has encountered significant challenges with conventional teaching methods. When relying heavily on theoretical instruction and limited hands-on experience, these approaches often fail to effectively convey the complex operations of gas turbines. The practical training is costly and challenging, leading to gaps in trainees' understanding and preparedness for real-world scenarios. Augmented Reality (AR) offers a solution by seamlessly integrating digital information and virtual objects into real-world environments, providing immersive and interactive experiences that can enhance and transform traditional learning methods in the gas turbine industry.

This paper explores the development of an innovative AR application specifically designed to enhance gas turbine training at a technical training and learning centre. By utilising AR technology, the application allows trainees to interact with detailed 3D models of gas turbines, enabling them to understand turbine components and operations comprehensively without the need for physical access to the machinery. This approach improves training effectiveness and addresses the inherent risks associated with traditional hands-on methods.

The correlation between AR and gas turbine training forms the core of this study, highlighting how interactive features, such as QR code-based 3D model recognition, can revolutionise the learning experience. This paper outlines the objectives, methodologies, and key findings of the project, demonstrating the potential of AR to transform industrial training and motivate trainees to engage more deeply with complex technical subjects.

Literature Review

AR technology has emerged as a powerful tool across various industries. AR enhances the training and education sectors by integrating digital content with the physical world. This literature review explores the application of AR in technical training, with a focus on its implications for gas turbine training.

AR has seen widespread adoption in technical training, especially in aviation, manufacturing, and engineering sectors. Bhatt (2022) highlights that 88% of medium-sized companies utilise AR, emphasising its capacity to superimpose digital data onto real-world objects, offering practical training experiences. In gas turbine training, AR facilitates the simulation of complex turbine systems, allowing trainees to interact with virtual representations and gain a deeper understanding of turbine operations.

Research by Bakri et al. (2019) underscores the significance of 3D modelling in education, noting its effectiveness in helping students visualise and comprehend complex phenomena.

The integration of AR further enhances these benefits by providing immersive environments where trainees can interact with and manipulate 3D models of turbine components. This interactive capability is crucial in gas turbine training, where understanding the intricate workings of turbines is essential.

Fade (2021) also highlights AR's interactive nature, discussing how AR can enhance both the learning and retention of knowledge among trainees and experienced professionals. In gas turbine training, AR enables hands-on learning experiences through virtual disassembly and inspection of turbine components, reducing the need for physical equipment and minimising associated risks.

Finally, Han et al. (2022) emphasise the importance of aligning AR applications with industry standards and best practices. In gas turbine training, AR must adhere to industry-specific regulations, safety protocols, and operational procedures to be effective. It has the potential to revolutionise traditional training methods in this field, offering dynamic and engaging learning environments that improve trainees' comprehension and performance.

Research Methodology

Agile methodology effectively manages evolving priorities in software development. This approach was applied to develop an AR application for gas turbine training, structured into six phases: Planning, Design, Development, Testing, Deployment, and Review.

The project was structured around several key phases, each with specific objectives and activities. In the Planning Phase, the primary goal was to develop a comprehensive roadmap for the project. This was accomplished through sprint planning sessions that effectively established timelines, assigned tasks, and set milestones, ensuring a clear path for the development process. Moving into the Design Phase, the focus shifted to creating the initial designs for the AR application. Activities such as storyboarding, UI/UX design, and the creation of 3D models were carried out, with valuable input from a technical training and learning centre guiding these efforts.

During the Development Phase, the objective was to build the AR application incrementally. This was achieved by implementing sprint features, integrating QR code recognition, and developing interactive components that enhanced the application's functionality— the Testing Phase aimed to ensure that the application met the required standards. Unit and integration tests were conducted, followed by gathering feedback from stakeholders, which informed the refinement of the application.

In the Deployment Phase, the focus was on delivering the final product. The application was compiled into a deployable format, final reviews were conducted, and training sessions were provided for the users to ensure they could effectively use the application. Finally, in the Review Phase, the project's success was evaluated, and lessons learned were identified through retrospective meetings with a technical training and learning centre. These discussions assessed the application's performance and explored potential improvements for future iterations.

Results and Discussions

In developing the AR application for gas turbine training, the project successfully enhanced the traditional training experience by integrating advanced technologies. Unity and Vuforia Engine were pivotal in creating realistic 3D models and interactive environments, which allowed trainees to visualise and interact with turbine components in real time. This interactive approach was crucial in improving the understanding of complex operating principles, which are often challenging to convey through conventional methods. The application focuses

on three main aspects: providing a functional graphical user interface for enhanced learning, offering practical access from anywhere and anytime, and creating an engaging and dynamic learning environment.

Graphical User Interface for Enhanced Learning

The user interface (UI) of the AR Gas Turbine Application was meticulously designed to enhance the learning experience by providing an intuitive and accessible platform. The UI allows trainees to easily navigate complex turbine systems, with features such as clear labels, interactive buttons, and visual cues that guide users through various components and processes. This structured approach ensures that users can focus on learning without being overwhelmed by technicalities, making the interface a powerful tool for bridging the gap between theoretical knowledge and practical application.

The UI's layout and functionality were also tailored to support different learning paces, allowing users to explore turbine operations at their speed. The interface offers interactive simulations, easy-to-access information, and dynamic visualisations catering to beginners and advanced users. This adaptability makes the application a resourceful learning aid and versatile tool that can be used in various training scenarios, effectively contributing to the overall educational goals. The snapshots of the application will further illustrate how these design choices facilitate a productive learning environment.



Figure 1 Gas turbine AR application

Practicality for Learning from Anywhere and at Any Time

The AR Gas Turbine Application demonstrates exceptional practicality by allowing users to learn from anywhere and anytime. Unlike traditional training methods that often require physical presence in specific locations, this application can be accessed via mobile devices or AR glasses. This flexibility ensures that users can use the application at home, on the field, or travelling. The snapshots of the app in use, alongside a large gas turbine model, illustrate how users can interact with realistic 3D representations of turbine components without needing to be physically present at a training site.

This capability extends the reach of training and integrates learning into users' daily routines. The application supports continuous education and skill development by providing access to high-quality, interactive training materials at their convenience. Exploring and understanding complex turbine mechanisms from various locations enhances the overall



Figure 2 The real gas turbine asset that is huge, heavy and non-portable requires traditional training on-site



Figure 3 Gas turbine in AR application mode allowing training and learning at any time and anywhere



Figure 4 UAT at a Technical Training and Learning Centre



Figure 5 Gas turbine AR application training sessions

learning experience, making advanced training more accessible and adaptable to individual schedules and environments.

Engaging and Dynamic Learning Environment

In developing the AR application for gas turbine training, the project successfully enhanced the traditional training experience by integrating advanced technologies. Unity and Vuforia Engine were pivotal in creating realistic 3D models and interactive environments, which allowed trainees to visualise and interact with turbine components in real time. This interactive approach was crucial in improving the understanding of complex operating principles, which are often challenging to convey through conventional methods. As illustrated in Figure 4, user acceptance testing (UAT) conducted at the Technical Training and Learning centre provided valuable insights, ensuring that the application met the rigorous standards required for practical training.

The application's ability to recognise QR codes and render corresponding 3D models provided an intuitive way for users to access detailed information about turbine components. This feature, essential for bridging theoretical knowledge with practical application, was refined to ensure accurate and responsive performance, significantly enhancing the training process. As shown in Figure 5, a training session was conducted at a technical training and learning centre for trainers to familiarise themselves with the application and equip them to teach trainees using this advanced tool effectively.

UAT Results

The UAT was conducted to evaluate the functionality and usability of the AR application developed for gas turbine training. This testing involved reviewing each application feature to ensure it met the defined acceptance

Table 1 UAT Result

No.	Feature	Acceptance Requirements	Accept	Reject	Tester's Remark
1	Welcome Screen	1. Presence of Project Title, UTP, and INSTEP logo. 2. INSTEP background. 3. 'Explore' button navigates to the Main Menu.	✓		
2	Main Menu	1. Instruction panel with 'Scan' button for QR code. 2. Live background. 3. Buttons for 'Sustainability Info', 'Section Segregation', and 'Process Flow'.	✓		
3	Sustainability Info	1. Displays information. 2. 'Home' button navigates to the Main Menu.	✓		
4	Section Segregation	1. 'Section Segregation' button opens scene. 2. Buttons for navigation and section display.	✓		
5	Section Segregation (Features)	1. 'Textured' button displays textured 3D model. 2. 'Transparent' button displays transparent model. 3. 'Highlight' button highlights components. 4. 'Show Only' displays selected components.	✓		
6	Gas Turbine Sections	1. 'Intake' button shows intake section. 2. 'Compression' button shows compression section. 3. 'Combustion' button shows combustion section. 4. 'Expansion' and 'Exhaust' buttons show respective sections.	✓		
7	Process Flow	1. 'Process Flow' button opens the scene. 2. 'Back', process flow description, and 'Next' buttons present. 3. Rotating 3D turbine. 4. 'Next' triggers animations of air entering intake, compressor, combustion, and exhaust.	✓		

criteria. Stakeholders performed the test from a technical training and learning centre for trainers, who provided feedback on the application's performance and user experience. Table 1 summarises the key results of the UAT, indicating whether each feature was accepted or rejected based on the predefined requirements.

Overall, the project demonstrated how AR technology could effectively improve training outcomes in technical fields, offering an engaging and comprehensive learning experience that prepares trainees for real-world challenges.

Conclusion

The successful completion of the AR Gas Turbine Application highlights the effectiveness of collaborative efforts and strategic project management in delivering innovative training solutions. The project met and exceeded industry standards by integrating cutting-edge AR technology, offering trainees an immersive and comprehensive understanding of gas turbine operations. Developing a user-friendly graphical interface ensured that learning was practically accessible anywhere and anytime, making the training process more flexible and convenient.

Collaboration with a technical training and learning centre was crucial in creating an engaging and dynamic learning environment tailored to specific training objectives. Despite challenges such as coordinating stakeholder input and aligning with external partners for 3D model creation, the project maintained its trajectory through adaptive communication and practical problem-solving strategies. These experiences underscore the importance of flexibility, proactive engagement, and teamwork in overcoming obstacles and ensuring the project's success. The insights gained will guide future advancements in training and learning methodologies and technological integration within the industry.

Acknowledgement

The authors would like to acknowledge the grant funder, Ministry of Higher Education Malaysia (MOHE) Grant FRGS (015MA0-148), for funding this research paper and publication.

References

Bakri, F., Sumardani, D., & Muliyati, D. 2019. Integrating augmented reality into worksheets: Unveil learning to support higher-order thinking skills. In *AIP Conference Proceedings, 2169(1)*. AIP Publishing.

Bhatt, T. (2021). *How augmented reality is changing the training industry. Training Magazine*. https://trainingmag.com/how-augmented-reality-is-changing-the-training-industry/

Fade, L. (2021). *Council post: The benefits of augmented reality for employee training*. Forbes.

Han, X., Chen, Y., Feng, Q., & Luo, H. 2022 Augmented reality in professional training: A review of the literature from 2001 to 2020. *MDPI*.

Combining Smartphone Technology and Microlearning as a Learning Strategy for the Thermodynamics Subject

Hazlina Husin*[1], Amni Haslinda Alpandi[2]
[1]Universiti Teknologi PETRONAS, Perak, Malaysia
[2]Universiti Teknologi Malaysia, Johor, Malaysia.
*hazlina.husin@utp.edu.my

Introduction

Lecturers often face challenges when teaching first-year students who struggle to achieve a deep understanding of new concepts before progressing to subsequent topics. This is because traditional pedagogy often makes lecturers depend solely on the predetermined timeline that is prepared earlier for their teaching portfolio. This scenario would result in knowledge gaps and uneven skill development among the students. Hence, by implementing a microlearning strategy, it is possible for students to fully grasp each concept by mastering bite-sized concepts before progressing to new topics. This learning strategy can also build a solid foundation among students for further independent learning. This learning strategy aims to enhance overall comprehension and increase retention of students by focusing on achieving proficiency in each concept before advancing.

Microlearning Strategy

Microlearning is an instructional strategy extended from mastery pedagogy introduced by Benjamin Samuel Bloom (Bloom, 1981). Mastery pedagogy is an instructional learning strategy where students must achieve mastery (for example, 90% and above based on a knowledge test) in pre-requisite knowledge assessment before the students can move forward and learn on the subsequent topics. If a student does not achieve the accepted level of mastery in the evaluation, the student is given additional support in learning and reviewing the concept and then tested again. Unlike mastery pedagogy, the microlearning strategy aims to address the issue of incomplete understanding to a particular student or a group of students by ensuring that all students achieve a similar level of proficiency in one concept before moving on to the next topic. This method enhances students' understanding of specific concepts and is conducted individually before progressing to the next topic (Dolasinski, 2020). Students will stimulate a list of learning activities as an act of repetition, which leads to closing the learning gaps and ensuring a more robust and cumulative knowledge acquisition (Hattie & Yates, 2013).

The effectiveness of the microlearning strategy depends on the implementation of this strategy in or outside the classroom. The microlearning strategy uses an approach where the content of a concept is introduced, recalled, and assessed in small, easily digestible units (bite-sized) (Mohammed, Wakil, & Nawroly, 2018; Samala, 2023). This approach is based on the principle that students will conduct a short, focused learning segment. This way, students can learn more effectively than lengthy, complex sessions. Typically, students will spend 5 to 15 minutes, allowing them to acquire specific knowledge or skills quickly. The key

benefit of the microlearning strategy includes enhancing students' focus retention as well as students' understanding of particular concepts. Since the content is segmented into bite-sized pieces, students can focus on one topic at a time. Ultimately, students can avoid cognitive overload, promoting better understanding and less stress.

Smartphone Technology

A core aspect of the United Nations' Sustainable Development Agenda 2030 is promoting quality education for all, focusing on making learning inclusive and equitable (Abid Haleem, 2022). Digital technologies, including smartphones, are essential to achieve this goal by enhancing access to education through mobile learning platforms and educational apps. Smartphones facilitate the detection of emission sources and support environmental sustainability by improving energy efficiency and promoting lower-carbon alternatives to fossil fuels. They also play a role in reducing or eliminating pollution and waste through smart technology solutions. Integrating smartphones into educational strategies and environmental efforts makes it possible to boost production and efficiency while advancing sustainability goals. These technologies collectively contribute to a more effective and inclusive education and environmental management approach.

Up to date, Table 1 shows a list of smartphone technologies that demonstrate microlearning strategies for educators. These applications exemplify how microlearning can be effectively implemented on mobile formats to facilitate convenient, engaging, and effective learning experiences for different types of students with individual needs, interests, and methods of processing information (Porter & Hernacki, 1992).

Research Methodology

In this study, a microlearning strategy was developed using the EdApp mobile application. The development stages are described in Figure 1.

Table 1 Smartphone technology and its application

Smartphone technology	Application
EdApp	This application creates a culture of learning in just a few minutes per day. Deliver highly targeted lessons so learners can quickly understand new concepts.
Duolingo	This application offers language learning through short, interactive lessons that users can complete in just a few minutes each day. It incorporates gamified elements to keep learners engaged.
Quizlet	This application uses flashcards and quick quizzes to help users learn and retain information. Its spaced repetition and active recall features are integrated into microlearning formats.
Memrise	This application uses brief, interactive lessons and spaced repetition to teach languages and other subjects. Its approach is designed to enhance retention and make learning enjoyable.
Elevate	This application provides short, personalised brain-training exercises to improve cognitive skills such as reading comprehension, writing, and math. Each exercise is designed to be completed in a few minutes.
Tinycards	This application uses flashcards to learn various subjects in short, engaging sessions. It leverages spaced repetition to reinforce knowledge.

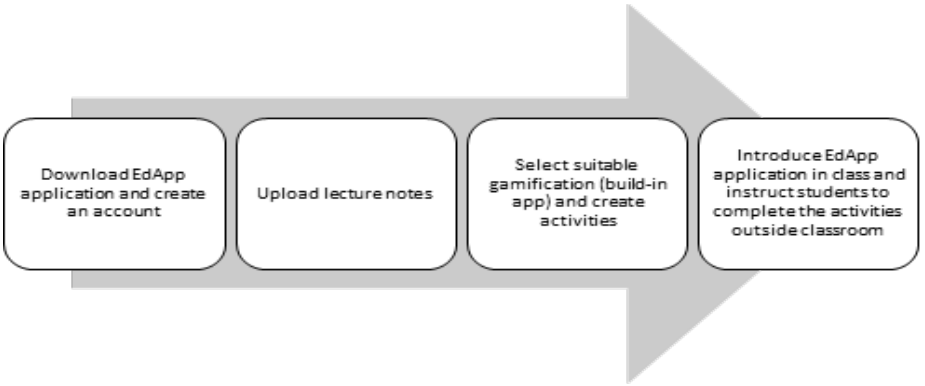
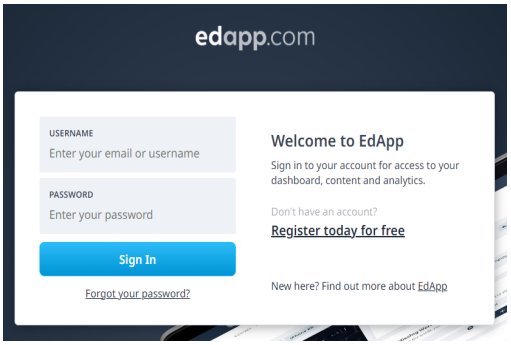


Figure 1 Process flow on the development of microlearning for Thermodynamic subject

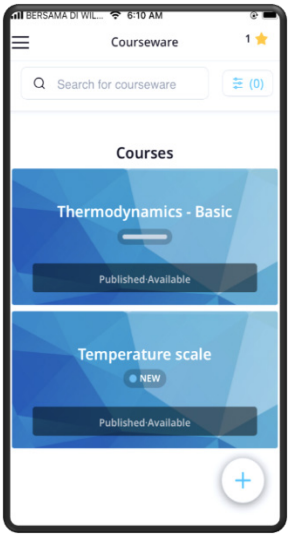
Then, an evaluation was conducted to observe the impact of the application on the course learning outcome (CLO) of the Thermodynamic subject. Thermodynamics is a subject offered to first-year students. Two cohorts of students are involved: May 2022 semester (no smartphone-microlearning strategy) and September 2022 (with smartphone-microlearning strategy). At the end of the semester, these students will answer a set of questions on CLO.



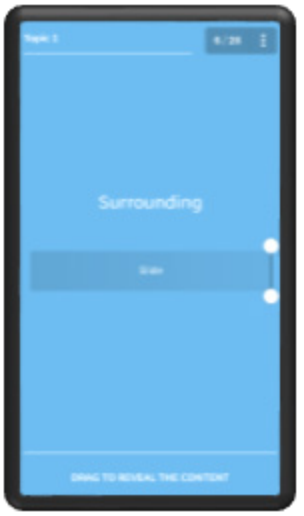
(a)

Result and Discussions

Figures 2a-2d show the features of EdApp mobile application that was developed for Thermodynamic subjects with empowered gameful experience that supports students' overall value creation yields to satisfactory active Learning (Alomari, Al-Samarraie, & Yousef, 2019; Alsawaier, 2018; Luis R. MurilloZamorano, 2021). Figure 3 shows a feature where the lecturer can observe the number of visits each student makes. This feature is also helpful for lecturers to observe the student's commitment to the subject. By observing the number of student visits, lecturers can motivate students to visit more.



(b)



(d)



(c)

Figure 2 Features in EdApp mobile application

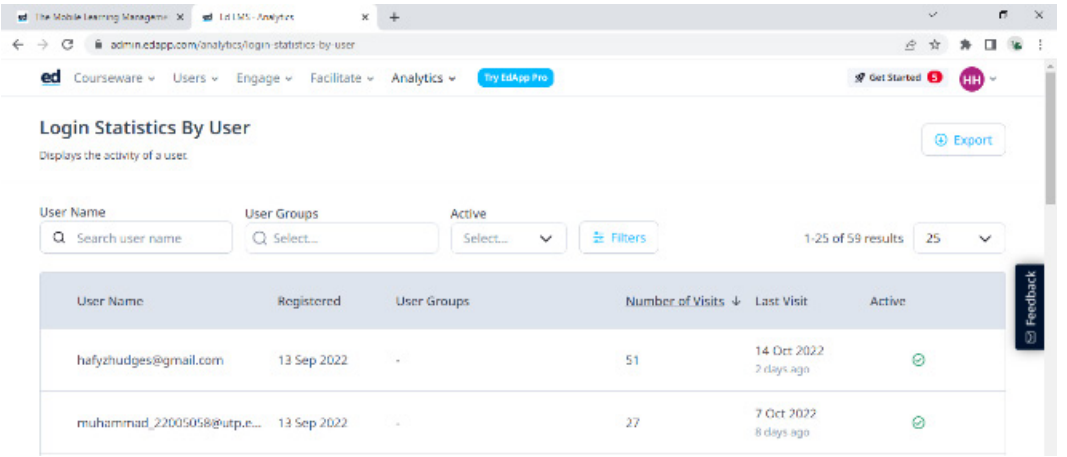


Figure 3 Analytics in EdApp mobile application for users check-in

Table 2 is the list of CLOs for the Thermodynamics subject. The impact was evaluated on 34 students from the May semester (without the microlearning strategy) and 66 students from the September semester (with the microlearning strategy). We discovered that incorporating microlearning has enhanced the focus on all the course learning outcomes. In the May semester (Figure 4a), no results showed low emphasis on CLOs. The highest medium emphasis was observed for CLO3, at 32.4%, while every CLO achieved over 70% for high emphasis. In the September semester (Figure 4b), medium emphasis levels were around 20%, whereas all CLOs reached 80% or higher for high emphasis. Additionally, no CLO was rated with a low focus by the students.

Microlearning is advantageous in deepening students' comprehension of smaller topics

and helping them retain this knowledge throughout the semester, particularly for the final examination. This benefit becomes evident through noticeable improvements in grading, reflecting the effectiveness of microlearning in reinforcing and sustaining understanding. As shown in Figure 5, in the May semester, there were four students with F grades, 5 with D grades, and 4 with D+ grades. Meanwhile, in the September semester, only one student had a D and one with a D+ grade. There was no failure this semester despite the number of students doubling.

Table 2 Course learning outcomes (CLO) for Thermodynamics subject

C L O No.	CLO statement
1	Explain the concepts of thermodynamic systems.
2	Apply the laws of thermodynamics to open and closed systems.
3	Calculate gas PVT properties using equations of states.
4	Apply phase equilibrium and solution thermodynamics concepts to hydrocarbon systems.

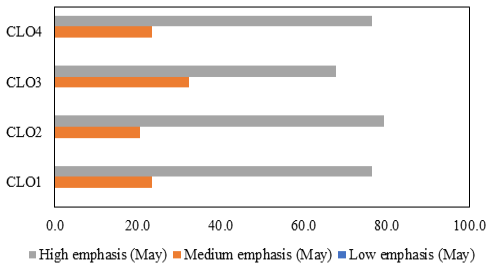


Figure 4a Analytics on course learning outcomes during May semester

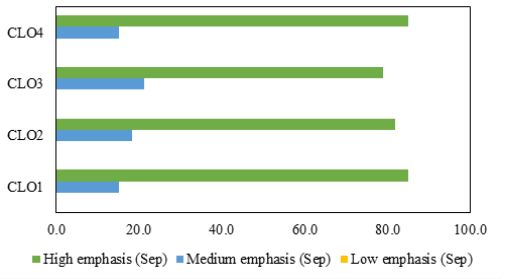


Figure 4b Analytics on course learning outcomes during the September semester

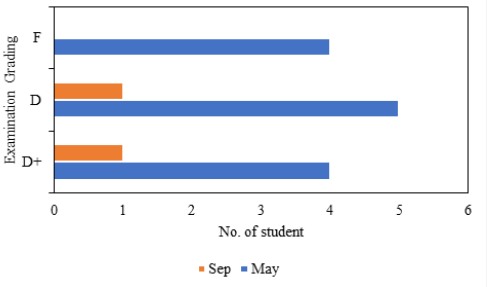


Figure 5 Reflection on the grading change during the final examination

Conclusion

Integrating smartphone features with a microlearning approach has positively impacted course learning outcomes and student performance by delivering precise, on-demand assistance tailored to individual learning needs. As a result of comparing 2-semester batch students (May and September), findings have shown that students have received better emphasis in their course learning outcome attainments while showing better grades in their final examinations. These results reflect the approach's effectiveness in enhancing overall academic outcomes.

Acknowledgment

The authors would like to acknowledge the Yayasan Universiti Teknologi PETRONAS (YUTP) grant (015LC0-383) and Universiti Teknologi PETRONAS (UTP) for providing financial support for the conference.

References

Abid Haleem, M. J., Mohd Asim Qadri, Rajiv Suman. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, pp. 275-285.

Alomari, I., Al-Samarraie, H., & Yousef, R. (2019). The role of gamification techniques in promoting student learning: A review and synthesis. *Journal of Information Technology Education: Research, 18*, pp. 395-417.

Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology, 35*(1), pp. 56-79.

Bloom, B. S. (1981). *All Our Children Learning - A Primer for Parents, Teachers, and Other Educators, New York: McGraw Hill.*

Dolasinski, M. J., & Reynolds, J. (2020). Microlearning: A New Learning Model. *Journal of Hospitality & Tourism Research, 44*(3), pp. 551-561.

Hattie, J., & Yates, G. C. R. (2013). *Visible learning and the Science of How We Learn*, Oxfordshire: Routledge.

Luis R. MurilloZamorano, J. Á. L. S., Ana Luisa GodoyCaballero, Carmen Bueno Muñoz. (2021). Gamification and Active Learning in higher education: is it possible to match digital society, academia, and students' interests? *International Journal of Educational Technology in Higher Education, 18*(15), pp. 1-27.

Mohammed, G. S., Wakil, K., & Nawroly, S. S. (2018). The effectiveness of microlearning to improve students' learning ability. *International Journal of Educational Research Review, 3*(3), pp. 32-38.

Porter, B. D., & Hernacki, M. (1992). *Quantum Learning: Unleashing the Genius in You* (pp. 356).

Samala, A. D., Bojic, L., Bekiroğlu, D., Watrianthos, R., Hendriyani, Y. (2023). Microlearning: Transforming Education with Bite-Sized Learning on the Go: Insights and Applications. *International Journal of Interactive Mobile Technologies, 17*(21), pp. 4-24.

Interactive Learning of Linear Algebra through Augmented Reality Visualisation

Zazilah May[*1], Gurwinder Singh[2]
[1]Universiti Teknologi PETRONAS, Malaysia
[2]Axg Intel Technologies India Pvt Ltd
[*]zazilah@utp.edu.my, gurwinder.singh@intel.com

Introduction

Linear algebra (LA) involves the study of vectors, vector spaces, linear transformations, and systems of linear equations and is crucial for fields like physics, engineering, and computer science. Its abstract nature often challenges students, making it difficult to grasp algebraic concepts and visualise problems. Learning LA can be challenging for many students. One of the reasons is the abstract nature of the subject. As one of the most abstract strands in mathematics, LA often poses difficulties for students (Quintero et al., 2015)). Augmented reality (AR) offers a promising solution by providing an interactive and immersive experience that helps students visualise and understand abstract LA concepts, such as matrices and vector spaces, in a three-dimensional space. AR enhances learning by overlaying digital content in the real world, improving comprehension and academic performance in linear algebra.

This visual representation helps students grasp the geometric interpretation of linear algebra concepts, which is often difficult to comprehend through traditional textbook explanations (Mutambara & Tsakeni. 2022). Research has shown that AR can effectively enhance students' understanding and retention of abstract scientific concepts (Munir et al., 2022). Furthermore, AR can adapt to students' individual learning needs and pace. A study found that students who used AR to learn linear algebra demonstrated improved understanding and engagement compared to those who relied solely on traditional instructional methods (Ginga & Zakariya, 2020).

AR offers innovative ways to visualise linear algebra concepts. One approach is vector visualisation, where AR overlays virtual vectors onto real-world scenes, enabling users to interact with vectors in three dimensions and understand operations like addition and projections. Another method is matrix transformations, where AR demonstrates how objects deform, rotate, or scale according to matrix transformations, helping users grasp concepts such as rotation matrices and shearing. AR also aids in visualising eigenvectors and eigenvalues by representing them as virtual arrows or lines, showing their effects on transformed objects. Additionally, AR can display systems of linear equations as virtual planes or surfaces, illustrating intersections and solution spaces. As an interactive learning tool, AR enhances engagement through virtual simulations and games, allowing students to explore and manipulate mathematical concepts more intuitively and interactively.

Augmented Reality for Visualisation

The following features of AR provide a useful tool for understanding 3D object manipulation in linear algebra.

Visualisation of transformation: The main strength of AR lies in its ability to visualise how linear transformations, like translation, rotation, and scaling, affect 3D objects. These make it easier and faster to understand linear algebra concepts.

Interactive Manipulation: Augmented Reality's interactive manipulation tool allows users to apply linear algebra operations directly to 3D virtual objects for an enhanced learning experience.

Real-Time Feedback: Users can use matrix multiplication or vector addition to manipulate and transform virtual objects in real time. As a result of this interactivity, users gain insight into how linear algebra concepts directly affect the behaviour and appearance of 3D objects.

Comparative analysis: AR enables comparative analysis by offering side-by-side displays of various transformed versions of an object, allowing learners to simultaneously compare different rotational matrices or scaling factors.

Guided Tutorials: AR applications provide beginner learners step-by-step guided tutorials and interactive examples. These tools enable real-time manipulation of virtual objects to teach linear algebra concepts in an immersive way. Integrating visualisations, interactivity, feedback, and analysis enhances understanding of how linear algebra affects 3D object manipulation, enriching the learning experience.

Methodology

Unity 3D is an effective tool for mathematical visualisation tools because it offers robust capabilities for building interactive designs with dynamic representations of complex concepts. The following are the steps involved in designing a visualisation framework.

Step 1: The design process begins by creating a scene for visualisation, including elements like lighting, cameras, and other assets. Initially, 2D scenes with basic interactivity are developed to establish functionality, as illustrated in Figure 1.

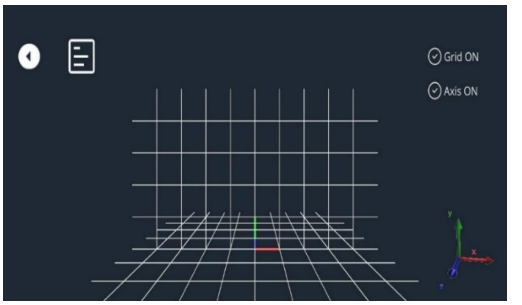


Figure 1 Non-AR interactive 3D cartesian plane

Step 2: A mathematical model is defined, and the most effective equations, formulas, or algorithms are chosen to generate data for visualisation. This data is mapped to visual elements in Unity. For instance, in a 3x3 matrix, the first column represents the basis vector for the x-axis, with similar mappings for the y-axis and z-axis, as shown in Figure 2.

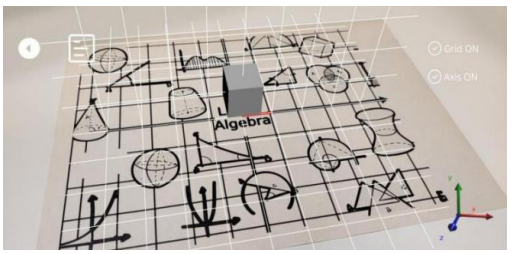


Figure 2 Sample activity with identity transformation matrix applied to Cube

Step 3: Visualisations are designed with a dynamic and enhanced understanding of mathematical concepts using interactive animation using object movement, transformation, or transitions. This creates an environment that allows users to manipulate

parameters or explore different scenarios. The main menu of a Unity application serves as the hub for navigating different sections and functionalities within the application. It typically includes various interactive elements and options that allow users to access different features and modes, as shown in Figure 3.

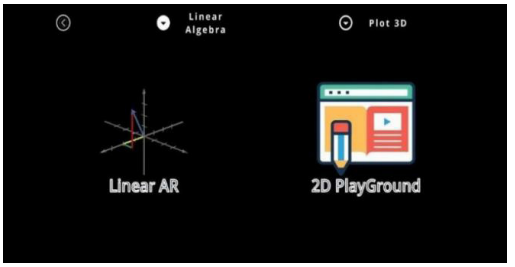


Figure 3 Main activity scene of application

Step 4: Designing an interface with controls like buttons and sliders is crucial for enabling users to interact with and adjust mathematical visualisations. This allows for variable adjustments, display changes, and data analysis. For example, users can modify an interactive 3x3 matrix to apply a scaling transformation, where the length of the x-axis basis vector is scaled up while the y-axis remains unchanged. The scaling effect is shown through adjustments in the basis vectors' lengths while preserving their directions, with the magnitude determined by the matrix.

Step 5: Graphs, charts, and custom plot representations provide more precise insights into visual contexts and additional libraries beyond Unity's default options can be used. For instance, Figure 5 illustrates a shearing effect by showing transformed basis vectors. The x-axis vector remains unchanged, while the y-axis vector is horizontally shifted; representing the shear transformation. This visual aids in understanding how linear transformations manipulate basis vectors and introduce shearing effects, enhancing comprehension of geometric concepts in two-dimensional spaces.

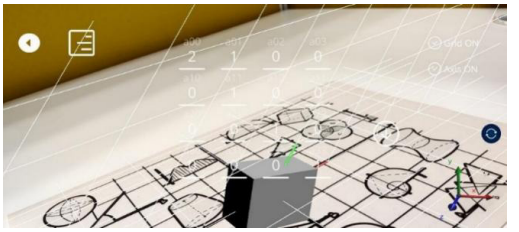


Figure 5 4x4 Transformation matrix to shear basis (i, j, k) Vectors and 3D object (Cuboid)

Step 6: Adding helpful annotations to provide formal explanations for additional insight may help users understand more about mathematical concepts, as shown in Figure 6.

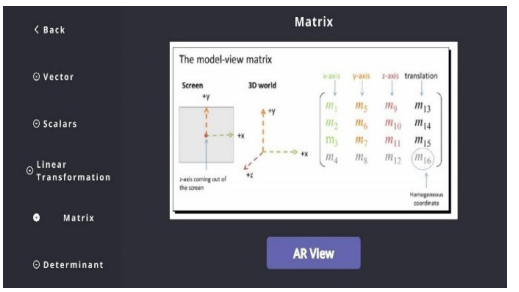


Figure 6 Linear algebra activities will start a scene with an AR view

Step 7: Regular testing is essential during the development of any visualisation tool to fine-tune performance, responsiveness, accuracy, and usability. Gathering input from users or domain experts helps improve the tool's ability to convey theoretical concepts and enhance its overall performance effectively. Accurate equations and clear visuals are vital for educational software success, with expert input ensuring precision and value.

Result and Discussions

In the experimental phase, 24 participants, consisting of students and educators from the Computer Science Engineering Department at

Chitkara University, India, and educators from Universiti Teknologi PETRONAS, Malaysia, provided feedback on their experience with the augmented reality-based visualisation application for learning transformation matrices. The students' recorded observations are as follows:

"I must express how much of a gem augmented reality app is for visual learners like me. The way it uses AR to bring linear algebra concepts to life is astonishingly amazing. The ability to interact with matrix multiplication and witness their transformations in real time has made this subject so much more accessible and exciting for me".

"It has undeniably sparked my newfound love for linear algebra".

"The incorporation of augmented reality in visualising vectors, matrices, and transformations is truly groundbreaking. This technology has profoundly enhanced my understanding of the subject matter and significantly increased my assurance".

"If you find yourself grappling with linear algebra. I highly recommend giving this app a chance, as it will surpass your expectations".
To quantitatively measure the effectiveness of AR in enhancing students' understanding, two sets of 5 similar questions on matrices are given to a group of 20 students. They must answer the first set without AR and the second one using AR. The student's performance improves by 40 per cent when using AR.

Conclusions

Matrices are vital in various fields, such as data analysis, computer science, mathematics, and physics. Augmented Reality (AR) enhances understanding of these abstract concepts by integrating them into the real world through immersive, three-dimensional interactions. AR allows users to visualise matrices as floating 3D objects over physical surfaces, creating a dynamic and engaging learning experience. This technology enables users to manipulate matrix size, shape, and viewing angles in real time, fostering a more profound comprehension of mathematical operations. By bridging the gap between abstract concepts and their real-world applications, AR encourages creative problem-solving and a more intuitive grasp of complex math, enhancing its relevance in everyday technologies like cell phones and cars.

References

Ginga, U. A., & Zakariya, Y. F. (2020). Impact of a social constructivist instructional strategy on performance in algebra with a focus on secondary school students. *Education Research International*, 2020, 1-8.

Munir, N. P., Anas, A., Suryani, L., & Munir, F. S. (2022). The Practicality of Geometry Learning Media based on Augmented Reality. Al-Khwarizmi: *Jurnal Pendidikan Matematika dan Ilmu Pengetahuan Alam*, *10*(1), 75-84.

Mutambara, L. H. N., & Tsakeni, M. (2022). Cognitive Obstacles in the Learning of Complex Number Concepts: A Case Study of In- Service Undergraduate Physics Student-Teachers in Zimbabwe. *EURASIA Journal of Mathematics, Science and Technology Education*, *18*(10).

Quintero, E., Salinas, P., González-Mendívil, E., & Ramírez, H. (2015). Augmented reality app for calculus: A proposal for the development of spatial visualisation. *Procedia Computer Science*, 75, 301-305.

Yilmaz, O. (2021). Augmented Reality in Science Education: An Application in Higher Education. Shanlax International *Journal of Education*, *9*(3), 136-148.

Metashield: Implementing Cybersecurity Awareness Among UTP Students during O'week

Lenuga M. Mathivaran, Savita Sugathan, Muniady Manoranjitham
Universiti Teknologi PETRONAS, Malaysia
savitasugathan@utp.edu.my

Introduction

Cybersecurity awareness is increasingly critical in today's digital era, especially within academic environments where students are major users of digital technologies. At Universiti Teknologi PETRONAS (UTP), students often lack sufficient knowledge to protect themselves from cyber threats despite the growing reliance on these technologies. This deficiency is compounded by traditional methods of cybersecurity education, such as email notifications and optional courses, which have proven ineffective in engaging students and raising awareness. The project "MetaShield" aims to address this issue by leveraging Metaverse technology to create an immersive and interactive cybersecurity awareness module introduced during UTP's Orientation Week. The primary objectives of this study are to assess the current level of cybersecurity awareness among UTP students, develop a Metaverse-based platform to enhance this awareness and evaluate the platform's effectiveness. A literature review highlights the importance of cybersecurity awareness among university students, who are frequent targets of cyber-attacks due to their extensive online presence (Al-Karaki, Itradat and Mekonen, 2023). Immersive technologies, particularly the Metaverse, offer innovative solutions to education by creating engaging learning environments that can significantly improve knowledge retention and application (Alqahtani, 2022;4). The findings indicate a substantial gap in cybersecurity knowledge among UTP students, alongside a strong interest in learning through immersive platforms. The MetaShield platform successfully engaged students, enhancing their understanding of cybersecurity concepts and demonstrating immersive technologies' potential in educational contexts.

Methodology

Preliminary Study

Preliminary studies are usually conducted before the system's implementation phase. These studies aim to expand the project's scope and gain a comprehensive understanding of the project's critical aspects, context, and requirements. This foundational work is essential for establishing a solid basis for the project's development. In this early research phase, a literature review and surveys will be undertaken (Chigbu et al., 2023). These methods are strategically selected to ensure a thorough exploration of the topic, facilitating the identification of key trends, challenges, and opportunities that will inform the project's direction.

Survey

The subsequent step in the preliminary study is conducting a quantitative survey. This research focuses on assessing the current cybersecurity

awareness level among University Technology PETRONAS (UTP) students and their preferences regarding immersive learning technologies, specifically the Metaverse. The survey aims to gather insights into students' knowledge, attitudes, and perceptions regarding cybersecurity and their receptiveness to Metaverse-based cybersecurity awareness modules. It consists of three sections covering demographics, cybersecurity awareness, familiarity with Metaverse, and their preferences. It will be distributed electronically, and analysis will involve generating visual representations such as bar charts to illustrate responses and trends. Insights from the survey will contribute to developing tailored cybersecurity awareness initiatives for UTP students.

Agile Methodology



Figure 1 Agile

The Agile methodology was chosen for MetaShield, is an iterative approach to software development and project management that prioritises flexibility, collaboration, and user feedback (Moallem, 2018; Sviridova et al., 2023). The process began with the planning phase, where the project's objectives, scope, timeline, and key milestones were defined using tools like Gantt charts to ensure timely delivery. Next, the requirement analysis phase involved gathering user needs through surveys to assess UTP students' cybersecurity awareness and comfort with the Metaverse platform. These insights informed the design phase, where storyboards and virtual environment prototypes were created. It focuses on layout, user interactions, and navigation within the Metaverse platform (Bale et al., 2022). The development phase followed, where a functional prototype of the cybersecurity module was built with iterative updates of continuous feedback. Finally, the testing and review phase involved a survey-based evaluation with UTP students during Orientation Week and a design thinking workshop with 16 students from De La Salle University, Philippines. Both phases provided valuable feedback on usability, effectiveness and user experience, which was analysed to refine the platform. This ensured the final product was robust and user-friendly and met the needs of UTP students in enhancing cybersecurity awareness.

Results & Discussion

Survey results revealed that most UTP students possessed a neutral to low level of cybersecurity awareness, highlighting a significant gap in their understanding of essential cybersecurity principles. Despite the frequent use of digital technologies, many students lack the knowledge to protect themselves against common cyber threats, such as phishing, malware, and data breaches. However, the survey also uncovered a strong interest among students in engaging with cybersecurity education delivered through innovative and interactive methods, such as an immersive platform like the Metaverse. During the user testing phases, the MetaShield platform effectively addressed this gap. Students who interacted with the platform reported higher levels of engagement and found the immersive environment both enjoyable and educational. The platform's interactive features, such as simulations and quizzes, helped students better grasp complex cybersecurity concepts, improving their overall awareness and understanding.

Furthermore, sessions conducted with De La Salle University students provided additional insights into the platform's potential. Participants offered constructive feedback on the usability and content of MetaShield, suggesting enhancements such as incorporating more real-world scenarios and gamification elements. This feedback emphasised the platform's potential as a powerful cybersecurity education tool, capable of increasing student engagement and fostering a deeper and more practical understanding of cybersecurity measures. The findings suggest that MetaShield could be a model for similar initiatives to improve cybersecurity awareness in educational settings. Figure 2 illustrates the final storyboard of MetaShield.

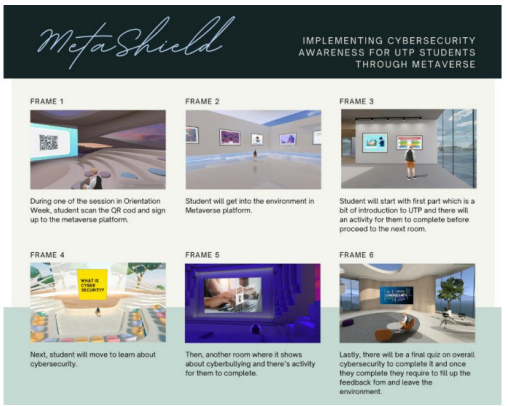


Figure 2 Final Storyboard

First Room: Intro to UTP

Figure 3 illustrates the first room, the Intro to UTP Room, and the starting point in the Metaverse platform. This room serves as the starting point for students entering the Metaverse environment. After logging in, students complete their registration at a kiosk and collect their O'Week kit. They can view the UTP Campus Map slide and enter the hall to explore further activities. The room includes four stations with tasks such as watching a welcoming video, learning about UTP through various modules, and completing quizzes. After the students log into the Metaverse environment, they will arrive at the entrance point labelled "Start Here." A tab in the bottom left corner will provide the user with step-by-step instructions on what to do next.



Figure 3 Intro to UTP Room

Second Room: Cybersecurity Room

Figure 4 illustrates the second room, the Cybersecurity room. In this room, students explore cybersecurity concepts. They can navigate through the area, accessing information displayed on the walls. A key activity involves watching a comprehensive video on cybersecurity. After engaging with all the content, students locate a point that transports them to the next room. This room aims to provide an in-depth understanding of cybersecurity principles and practices.

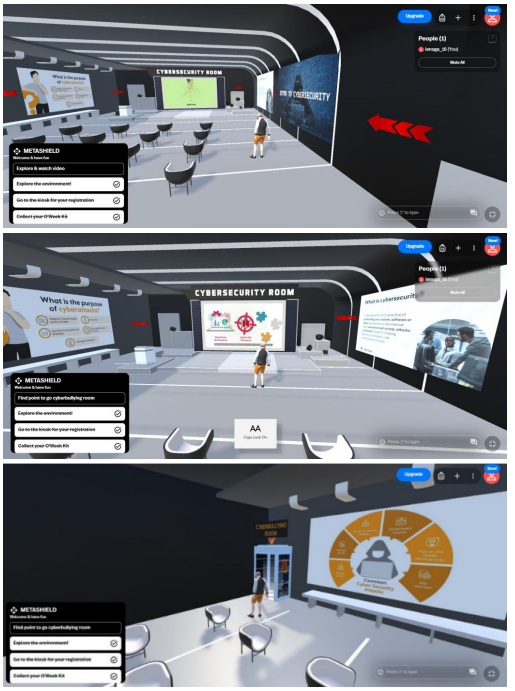


Figure 4 Cybersecurity Room



Figure 5 Cyberbullying Room

Third Room: Cyberbullying Room

Figure 5 illustrates the last room, which is the Cyberbullying room. The final room focuses on cyberbullying awareness. Students follow directions to complete various tasks, including watching an introduction video on cyberbullying and viewing informative posters. They take a quiz on cyberbullying, watch an example scenario video, and complete a word search related to cybersecurity. The room also includes a video on preventing cyberbullying and a final quiz covering overall cybersecurity. Before exiting, students fill out a feedback form to provide their insights and suggestions.

User Testing

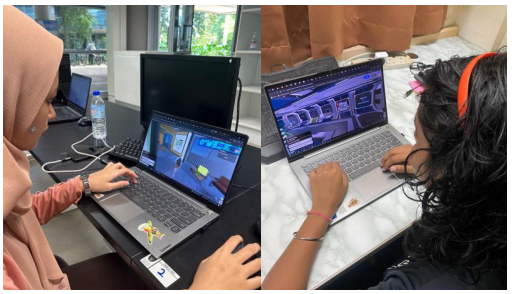


Figure 6 User Testing among UTP students



Figure 7 DLSU Workshop

Contribution

Teaching & Learning

The MetaShield project significantly contributes to the field of education, particularly in how cybersecurity is taught to university students. By integrating the Metaverse as a platform for learning, MetaShield moves beyond traditional, passive education methods such as lectures and email notifications towards an immersive, interactive approach. Through experiential learning, this interactive platform enhances student engagement and retention of complex cybersecurity concepts. The project showcases the potential of immersive learning environments, where students actively participate in simulations, quizzes, and tasks within a virtual world. This shift from passive to active learning contributes to a deeper understanding of cybersecurity principles, encouraging students to apply what they learn in real-world contexts. As immersive technologies like the Metaverse continue to evolve, the educational implications of MetaShield serve as a model for integrating similar technologies into other areas of study (Alqahtani, 2022; Al-Karaki, et al., 2023).

Metaverse in Education

One of the pioneering aspects of MetaShield is using the Metaverse as an educational tool. The Metaverse allows students to engage with course content in a way that traditional methods cannot match, fostering an interactive and gamified learning experience. In this project, students learn about cybersecurity threats in a virtual environment where they can interact with the content, solve problems, and receive immediate feedback. This innovative use of the Metaverse has broader implications for educational practices, highlighting the potential of virtual environments to enhance learning in various disciplines. MetaShield illustrates how universities can implement Metaverse-based learning modules to engage students more effectively, making education informative but also immersive and enjoyable.

Cybersecurity Awareness

The project raises cybersecurity awareness among students at UTP by making cybersecurity education more accessible and engaging. MetaShield's platform introduces essential cybersecurity concepts, such as phishing, malware, and cyberbullying, in an immersive environment during UTP's Orientation Week. The interactive nature of the platform allows students to navigate through different virtual rooms, each designed to address key aspects of cybersecurity, ensuring a practical understanding of these concepts. The platform's success during user testing with UTP students and feedback from students at De La Salle University in the Philippines demonstrates its effectiveness in addressing the knowledge gaps in cybersecurity. Other universities can potentially adopt this project as a model for improving cybersecurity education through immersive learning technologies (Fattah & Wagimin, 2023).

Future Expansion

MetaShield's success at UTP allows it to expand its use to other educational institutions. The Metaverse platform can be adapted to a wide range of academic fields beyond cybersecurity, offering a new approach to learning that prioritises interaction, engagement, and experiential knowledge. The project's success demonstrates the potential of immersive learning environments to transform education, making it a valuable contribution to the future of teaching and learning in the digital age (Chigbu et al., 2023).

Conclusion

The MetaShield project successfully demonstrated the potential of the Metaverse in enhancing cybersecurity awareness among UTP students. The platform's interactive and immersive nature made it an effective tool for engaging students and imparting

essential cybersecurity knowledge. Future recommendations include continuous updates to the platform, incorporating real-world scenarios, and expanding its use to other universities to improve cybersecurity education further.

Acknowledgement

The author would like to acknowledge the grant funder, Yayasan Universiti Teknologi PETRONAS (YUTP) [015LC0-523], for funding this research paper and the reviewers for the constructive feedback.

References

Alqahtani, M. A. (2022). Factors Affecting Cybersecurity Awareness among University Students. *Applied Sciences*, *12*(5), 2589. Doi:10.3390/app12052589

Al-Karaki, J. N., Itradat A. and Mekonen S. (2023). Immersive Cybersecurity Teaching/ Training Using Gamification on the Metaverse: A Hands-On Case Study, IEEE Intl Conf on Dependable, Autonomic and Secure Computing, 0101-0108.

Bale, A. S., Ghorpade, N., Hashim, M. F., Vaishnav, J., & Almaspoor, Z. (2022). A Comprehensive Study on Metaverse and Its Impacts on Humans. *Advances in HumanComputer Interaction*, 2022, e3247060. Doi:10.1155/2022/3247060

Malaysia Reveals a School-Based Metaverse Education Program. (2024, March 13). https://metanews.com/malaysia-reveals-a-metaverse-based-education-program/

Yeoh, A. (2023, December 6). Cybersecurity report ranks Malaysia as eighth most breached country in Q3 2023. *The Star.* https://www.thestar.com.my/tech/technews/2023/12/06/cybersecurity-report-ranks-malaysia-as-eighth-most-breachedcountry-in-q3-2023#:~:text=Cybersecurity%20company%20Surfshark%20has%20ranked

Fattah, A., Wagimin & Nurlia, (2023). Enhancing cybersecurity awareness among university students: a study on the relationship between knowledge, attitude, behavior, and training, *JSI : Jurnal Sistem Informasi (E-Journal), 15*(1), 3124 – 3138.

Moallem, A. (2018). Cyber Security Awareness Among College Students. Advances in Intelligent Systems and Computing, 782, 79–87. Doi:10.1007/978-3-319-94782-2_8

Sviridova, E., Yastrebova, E., Bakirova G. & Rebrina, F. (2023). Immersive technologies are an innovative tool to increase academic success and motivation in higher education. *Frontiers in Education*. Doi: 10.3389/feduc.2023.1192760

Chigbu, U. E., Atiku, S. O., & Du Plessis, C. C. (2023). The Science of Literature Reviews: Searching, Identifying, Selecting, and Synthesising. *Publications*, 11(1), 2. https://www.mdpi.com/2304-6775/11/1/2

VRE. (n.d.). VR Cyber Security & Augmented Reality Cyber Security Training. VRE. Retrieved March 25, 2024, from https://www.virtualrealityexp.co.uk/vr-cybersecurity-training-and-assessment/

Development of Immersive Virtual Reality Module for High Voltage Laboratory

Mohd Fakhizan bin Romlie
Universiti Teknologi PETRONAS, Malaysia
fakhizan.romlie@utp.edu.my

Introduction

Virtual reality (VR) has proven transformative in educational settings by offering immersive, interactive experiences that significantly enhance student engagement and learning outcomes, as shown in recent research by (Vats & Joshi, 2024). High voltage engineering is a crucial topic that must be addressed in the electrical engineering curriculum, mainly to expose students to fundamental high voltage safety standards and their application in the industry. In addition, conducting high-voltage experiments is essential to give hands-on experience, safety training, and familiarity with the equipment. However, due to safety regulatory compliance issues and cost, the HV lab is unavailable in many universities, including Universiti Teknologi PETRONAS (UTP). In addressing the issue, a VR HV lab module can provide an alternative at a lower cost and a safe learning environment (Zhang, Wu, & Li, 2012). The main objective of this presentation is to share the development process of an immersive VR high-voltage lab module and present initial findings from its utilisation by the first group of students.

Development Process

The process begins with a needs assessment to recognise that a virtual lab is a crucial substitute for a high-voltage lab. Then, in the design and planning stage, the VR storyboard was created to visualise the experience and interaction used within the VR environment and develop the content for the VR module. For the content, we decided to capture 360-degree videos from the actual laboratory at Universiti Malaysia Perlis (UniMAP). The technical development of the module was carried out by the experts at the Centre of Teaching and Learning (CeTAL) at UTP, who perform essential programming and instructional design. The developed module underwent thorough testing and evaluation, utilising feedback from a few lecturers to refine the user experience before being implemented with the first group of students in July 2024.

Overview of the VR Module

The module includes a laboratory safety briefing, virtual tour, experiments, and quiz. The briefing ensures students understand the importance of safety protocols in a high-voltage laboratory. The virtual tour offers an immersive, 360-degree view of the laboratory setup. It allows students to explore the lab space, understand the layout of the equipment, and familiarise themselves with the tools they will be using during the experiments. This VR module also allows students to conduct high-voltage experiments in a virtual environment. The experiments are designed to simulate real-life scenarios, enabling students to manipulate lab equipment, take readings, and observe

outcomes without the inherent dangers of a physical high-voltage lab. These simulations provide hands-on learning experiences, fostering a deeper understanding of theoretical concepts. To engage in immersive learning using the module, users must wear a VR headset and use controllers for interaction.

Result and Discussions

The module has been utilised by 17 undergraduate students from UTP taking a Power System course in July 2024. The survey results in Figure 1 reveal a strong positive reception of the VR module utilised in high-voltage engineering education. A notable 58.8% of participants selected "Completely Agree," indicating that they found the module highly beneficial for their learning. Additionally, 35.3% chose "Agree," reflecting general satisfaction among the students. Only 5.9% responded with "Neutral", suggesting minimal dissatisfaction. No student disagrees that the module is helpful for their learning. These findings demonstrate that most students recognise the value of immersive learning experiences in enhancing their understanding of complex engineering concepts. Overall, the results underscore the effectiveness of the VR module in facilitating a more engaging and informative educational environment.

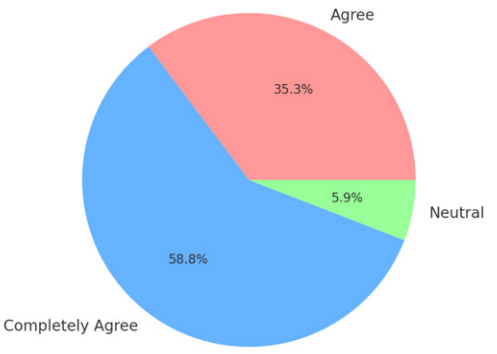


Figure 1 Survey results

In reflecting on the virtual lab, a student, Teoh Hun Seng, noted,

"The virtual lab provides a thorough exploration of high voltage equipment and experimental procedures. It offered an opportunity to engage with essential safety protocols and conduct experiments virtually, including AC and DC voltage generation and breakdown tests. This comprehensive approach gave a detailed understanding of high voltage principles and their practical applications in a controlled environment. Initially, I felt worried about the complexity of high-voltage systems and the potential hazards associated with them. However, the structured guidance and interactive nature of the virtual lab eased these concerns. The clarity of instructions and the ability to visualise and manipulate the equipment in a virtual setting made the experience both engaging and educational. This shift in perspective helped me gain confidence and interest in the subject matter".

Conclusion

In conclusion, the development process of the VR high voltage lab and its initial findings have been discussed in this presentation. Additionally, this research will be conducted to evaluate the module's effectiveness further.

Acknowledgement

Thanks to UTP for their support through the Scholarly of Teaching and Learning (SoTL) grant 015LF0-068 and to Universiti Malaysia Perlis for granting us access to their High Voltage Lab.

References

Vats, S., & Joshi, R. (2024). The Impact of Virtual Reality in Education: A Comprehensive Research Study. Transfer, Diffusion and Adoption of Next-Generation Digital Technologies. *TDIT 2023. IFIP Advances in Information and Communication Technology,* Doi:10.1007/978-3-031-50204-0_11

Zhang, X., Wu, Y., & Li, J. (2012). Application of virtual experiment in high-voltage engineering education. *IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)*, (pp. 239-243).

Course Delivery Via Blended Learning Supported by Flipped Classrooms and Active Learning Techniques

Chew Thiam Leng*, Lam Man Kee, Chai Yee Ho
Universiti Teknologi PETRONAS, Perak, Malaysia.
*thiamleng.chew@utp.edu.my

Introduction

Principles of Chemical Engineering (PCE) is one of the core courses for first-year students in the Chemical Engineering Department Universiti Teknologi PETRONAS (UTP). This course is designed to equip students with the fundamentals of chemical engineering, such as introduction to the chemical industry, chemical engineering calculations, problem-solving techniques, material balance, energy balance for various systems, and combined material and energy balance.

However, this course frequently encountered poor academic performance and high failure rates in different academic semesters. One of the primary root causes is the vast syllabus content designed for PCE despite the limited time allocated for conventional physical lecture time. During the traditional lectures, limited time, insufficient practice, and problem-solving activities, coupled with low student engagement, also contributed to the poor academic performance of the students.

To change the traditional teaching method, we implemented blended learning supported by flipped classrooms and active learning techniques for the course PCE. This study explored whether this blended learning model could optimise the students' learning time, create a more attractive learning environment, and improve the learning process.

Literature Review

Active learning techniques are well-recognised and have proven effective in educational settings, boosting student engagement and learning outcomes. Tannous (2024) highlighted that active learning techniques such as think-pair-share, role-playing, think-aloud, peer teaching, in-class group discussions, and gamification are most applied in chemical engineering courses. It was found that student engagement steadily increased over the semester in the gamified active learning approach, which reflects the increase in motivation and familiarity with the instructor's teaching style (Tannous, 2024).

Blended learning is a multifaceted teaching approach that combines offline instruction, online learning resources, and reciprocal evaluation and feedback between students and teachers. Blended learning is essential in engaging the teachers and students to participate actively in the teaching and learning activities. In the blended learning approach, the teacher will transform from the traditional leading role to the supporting role and become the supervisor; meanwhile, the students will transform from the conventional supporting role to the leading role and become the centre and active element of the teaching link. The students could be encouraged to engage actively in learning by implementing mixed teaching methods (Yang et al., 2024).

The flipped classroom approach has gained popularity among different blended learning models. The flipped classroom approach has benefits in teaching and learning activities compared to traditional teaching and learning methods. The flipped classroom approach is a teaching method that eliminates in-class lectures, allowing classroom time to be used for deeper exploration of topics through peer discussions and problem-solving activities guided by instructors. Pre-class materials such as video recordings are commonly provided to the students to replace the eliminated in-class lectures. In the flipped classroom approach, active and social learning activities occur during the classes, while most information delivery happens outside the classes (Kong et al., 2024).

Liu et al. (2024) assessed the effect of blended learning on learning outcomes for medicine courses. It was found that blended learning can efficiently enhance the participants' learning outcome, which includes self-evaluation, test, and learning satisfaction, compared to traditional teaching and learning methods (Liu et al., 2024).

Wu et al. (2024) implemented the flipped classroom approach in an implant dentistry hands-on course. Despite limited class time, the learning efficiency could be enhanced more than the traditional approach. Most students valued the pre-class video lectures introduced in the flipped classroom approach (Wu et al., 2024).

Kong et al. (2024) researched flipped classrooms in foreign language teaching in Chinese higher education. The uploaded learning materials, which can be accessed easily from anywhere at any time, have enhanced the students' interest in classes (Kong et al., 2024).

On the other hand, Yang et al. (2024) introduced the approach combining flipped classroom and case-based learning into the pathophysiology course for international students. It was reported that the online flipped classroom based on case-based learning has greatly enhanced the learning enthusiasm and participation of the students, compared to traditional teaching methods. In addition, this approach has also significantly improved the students' problem-raising and problem-solving abilities (Yang et al., 2024).

Research Methodology

The framework of blended learning supported by flipped classrooms and active learning techniques in current work is shown in Figure 1. The framework provides pre-class teaching materials, in-class activities, and post-class activities, followed by surveys and Continuous Quality Improvement (CQI).

Pre-Class Teaching Materials

The pre-class video recordings were provided to the students before the classes. Students were required to watch the videos before the classes.

In-Class Activities

The classes started with short recaps of the pre-class videos to ensure students had watched the videos before the classes. Peer discussions, problem-raising activities and problem-solving activities were conducted in the classroom to explore topics more deeply. Different active learning activities, including reflection, recaps, opening questions, think-pair sharing, and in-class teams, were implemented during the teaching and learning activities in the classroom. In addition, formative assessment was conducted using Kahoot and Socrative to monitor student learning.

Post-Class Activities

The students were required to solve a project in a team of 5 members. In the project, the

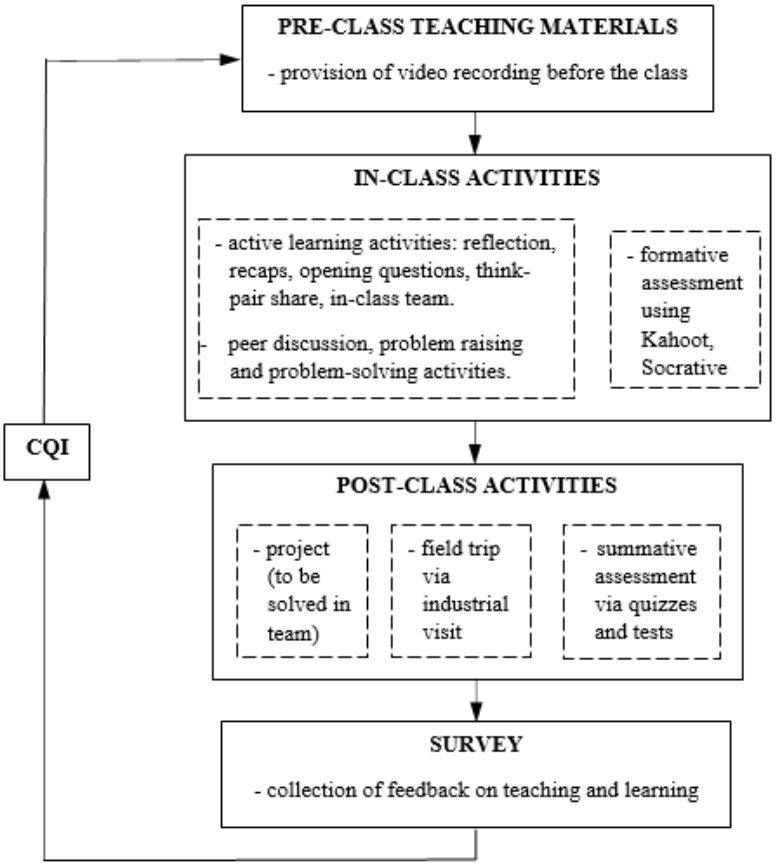


Figure 1 The framework of blended learning supported by flipped classroom and active learning techniques in current work

students had to solve chemical engineering problems relevant to mass and energy balance. The submitted projects by the students were evaluated.

In addition, the students were exposed to field trips via industrial visits outside UTP. The students were brought to the industry so that they could visualise and understand how the unit operations operate in a realistic industry. After the industrial visit, the students were required to answer a quiz relevant to their visit. Summative assessments via quizzes and tests were also conducted to evaluate the student's learning.

Survey

The students' feedback on teaching and learning was collected via a survey.

Continuous Quality Improvement (CQI)

CQI was performed based on the monitoring of the following outcomes:

a. Formative assessment
b. Summative assessment
c. A survey of the students

Results and Discussions

Figure 2 shows the statistics for the feedback collected from the students via survey. It could be observed from the statistics that more than half of the students benefit from blended learning supported by flipped classrooms and active learning techniques.

The active learning strategies (focused listing, opening question, think-pair-share, reflection, in-class team) that have been implemented in this course were beneficial in improving the learning by most of the students in this course compared to traditional lecturing. The active learning techniques made the teaching and learning environment more engaging and dynamic compared to the dullness of traditional lectures. In addition, the activities using innovative tools (i.e., KAHOOT) made the learning more interesting, as most of the students in this course agreed. Besides, the formative assessment conducted using Kahoot and Socrative in the classes was able to help students identify their strengths and weaknesses for further improvement.

Approximately 92% of students in this course agreed that the pre-uploaded teaching materials before the classes are beneficial in preparing them better for the lecture than the traditional lecture method. The pre-class video provided the essential syllabus content of the course to the students before the class. However, it should be noted that about 5% of students in this course disagreed that the pre-uploaded teaching materials before the classes in this course were beneficial in preparing them better for the lecture. This might be because they were unable to understand and interpret the videos themselves. Lastly, 58% of the students in this course agreed that the flipped classroom activities implemented in this course are beneficial in optimising their learning (in the aspect of learning time and learning pace) compared to the traditional lecture method. This is because they can watch and re-watch the videos anytime and anywhere, according to their needs. Consequently, they can control their own learning pace. However, it was found that a tiny minority of the students did not engage actively during the in-class activities. Hence, perhaps a smaller class size could be considered for conducting the in-class activities more efficiently under the supervision and guidance of 1 lecturer in the future.

Conclusion

Blended learning supported by flipped classrooms and active learning techniques has been successfully implemented in the course Principles of Chemical Engineering. More than half of the students benefit from blended learning. The active learning techniques made the teaching and learning environment more engaging and dynamic compared to the dullness of traditional lectures. Providing pre-class teaching materials before class and following them with in-class peer discussion, problem-raising, and problem-solving activities will provide a deeper exploration in the classroom, and the student's learning time could be optimised. They can watch and re-watch the videos anytime and anywhere, according to their needs. In addition, they can control their own learning pace. It is recommended that classes with smaller sizes be considered for the delivery of more efficient in-class activities under the supervision and guidance of one lecturer.

Acknowledgement

The author would like to acknowledge the support from the Department of Chemical Engineering, UTP, and UTP.

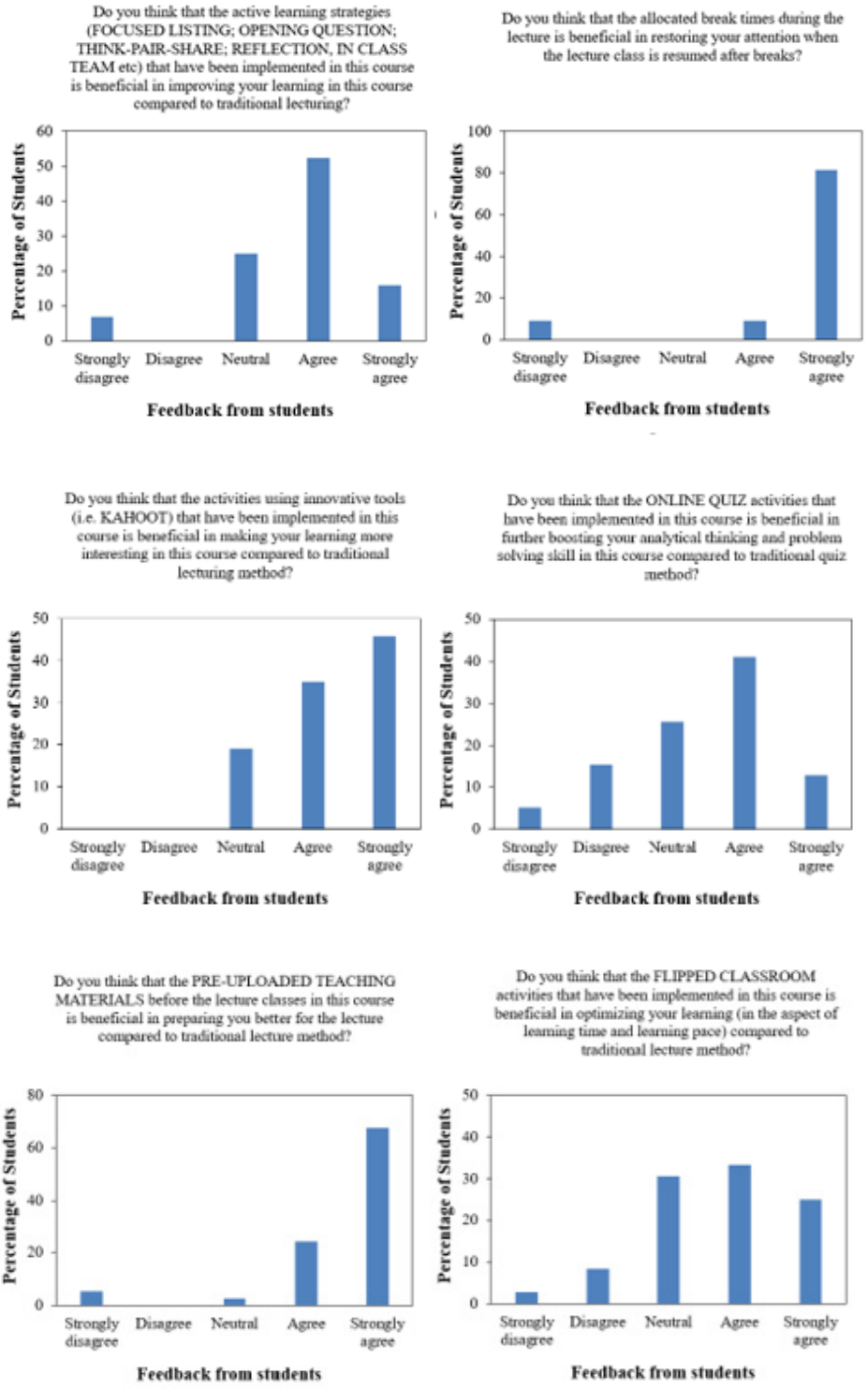


Figure 2 Statistics of the feedback that has been collected from the students via survey

References

Kong, W., Li, D. & Guo, Q. (2024). Research on flipped classrooms in foreign language teaching in Chinese higher education. *Humanities and Social Sciences Communications*, 11, 525.

Liu, K., Liu, S., Ma, Y., Jiang, J., Liu, Z., Wan, Yi. (2024). Comparison of blended learning and traditional lecture method on learning outcomes in the evidence-based medicine course: a comparative study. *BMC Medical Education*, 24, 680.

Tannous, J. H. (2024). Assessing the Impact of Diverse Active Learning Strategies in Gender-Segregated STEM Classrooms. 2024 IEEE Global Engineering Education Conference (EDUCON), Kos Island, Greece, 2024, pp. 1-7.

Wu, T., Xia, H., Sun, W., Ge, Y., Liu, C., He, F., Cheng T., Zhao, Y., Chen, S. (2024). Effectiveness of a flipped classroom for undergraduates in implant dentistry hands-on course. *BMC Medical Education*, 24, 545.

Yang, W., Zhang, X., Chen, X., Lu, J., Tian, F. (2024). Based case-based learning and flipped classroom as a means to improve international students' active learning and critical thinking ability. *BMC Medical Education*, 24, 759.

Innolead-Biz: Transformative Teaching and Learning Model For Innovation In Education Course

Nurhasmiza Abu Hasan Sazalli, Wan Nur Asyura Wan Adnan, Wan Farah Wani Wan Fakhruddin,
Universiti Teknologi Malaysia, Malaysia
*nurhasmiza.kl@utm.my

Introduction

'InnoLead-Biz' represents the words 'innovation', 'leadership', and 'business', key factors in developing transformative teaching and learning methods focusing on educational innovation with significant emphasis on student-centred learning. Driven by the new norm change in the Malaysian higher education system that shifts from conventional face-to-face teaching to implementing the 21st Century teaching and learning approaches, InnoLead-Biz was created to help students produce innovative products with marketability value and help solve educational problems. The problems of previous learning methods, which only focus on input from lecturers and are too theoretical and lack perspective from the industry, are solved by InnoLead-Biz because this is in line with 21st Century learning methods that focus on creativity, critical thinking, real-world problem-solving, active and reflective learning and coupled with the application of entrepreneurial thinking and leadership.

The objectives of InnoLead-Biz are (i) to design a transformative teaching and learning model that integrates Problem-Based Learning (PBL), Innovation Design Model, Value Proposition Canvas (VPC), and Leadership Competency Model, (ii) to identify the effectiveness of the transformative teaching and learning model for students of the Innovation in Education course.

Literature Review

InnoLead-Biz is relevant to the 21st-century T&L approaches emphasising PBL. Other than that, other elements, namely VPC, Leadership Competency Model, and Innovation Design Model, have also been added in accordance with the needs of the Innovation in Education course.

Problem-Based Learning (PBL)

PBL is an instructional approach based on real-world problems (Savery & Duffy, 1995). Through this method, students are exposed to educational issues and concerns that occur around them and are allowed to deepen the problem before devising a solution to the problem through the product they produce. The focus of this method is self-learning, teamwork, mastery of communication skills, strategic leadership, responsibility, and a positive attitude among the students of this course. Teaching at this level should emphasise critical and critical thinking.

Value Proposition Canvas (VPC)

VPC (Osterwalder et al., 2014) has been used to ensure a fit between the innovative products produced and the market. Customer segments and proposed products to be created are emphasised to ensure that the products align with the needs of customers who are, on average, educators, teachers, education management lines, and other related parties.

Leadership Competency Model
This transformative teaching and learning approach has adopted the Leadership Competency Model developed by the Higher Education Leadership Academy (MOHE, 2009). In particular, Leadership Competency 2 (Cognition) has been highlighted to students because it relates to how they can understand situations, tasks, problems, opportunities, or knowledge. Leadership Competency 3 (Leading Others) is how students can build cooperation with others to foster a collaborative environment.

Innovation Design Model
The Inno-Lead-Biz model has adopted the ADDIE model (Peterson, 2003). The five main elements of ADDIE are Analysis, Design, Development, Implementation, and Evaluation. Elements of ADDIE have been adapted in Phases 2, 3, and 4 of the InnoLead-Biz Model.

Research Methodology

Employing a Design-based research (DBR) approach (Sandoval & Bell, 2004), this innovation involved developing iterative designs to develop knowledge that improves educational practices. The designs were tested in cycles of iterations and adapted and re-tested to gather more data. Three cycles of iterations were conducted, and the Impacts of each iteration were evaluated using interviews and qualitative data analysis. The participants were 2-course instructors of Innovation in Education and 47 postgraduate students who studied the subject. These doctoral students pursued the Master of Education course, and throughout the data collection, the course was conducted online.

Cycle 1: Analysis of practical problems by researchers and practitioners in collaboration. Data was gathered from instructors' reflection, focused group discussion, lecturer & students to find the weaknesses and strengths of the current teaching methods and areas for improvement. Findings of this stage formed conjectures to be tested in Design 1 (elements of transformative teaching).

Cycle 2: Tested conjectures of Design 1. The transformative teaching elements were implemented for 6 months. The components are integrated into the PBL approach and innovation design model. The findings of the Cycle 2 iteration were evaluated using interviews with the instructors and students, and refinements were made to produce Design 2.

Cycle 3: Tested conjectures of Design 2. Based on participants' feedback and the progress of their innovation product development assignments, components were added to improve the transformative element in the teaching practice. The impacts of the Cycle 3 iteration were evaluated using interviews with the instructors and students. Reflections and refinements were made to produce Design 3 and enhance solution implementation.

Result and Discussions

Finding 1
Based on the analysis from all the cycles, the transformative teaching and learning model that integrates PBL, Innovation Design Model, VPC, and Leadership Competency Model is translated into the InnoLead-Biz model, as shown in Figure 1.

Phase 1: Upskill
Lecturers obtain entrepreneurship knowledge formally and informally before and during teaching this course. Collaborations with industry players involved in developing innovative products are also built so that they can be invited to share knowledge with students. Through the understanding of entrepreneurship and exposure gained, the lecturer's way of thinking will change, and be able to see things from a different angle.
Phase 2: Educate
Based on the PBL approach, the P&P guides students to explore innovation-related problems in education. Teaching uses online collaborative

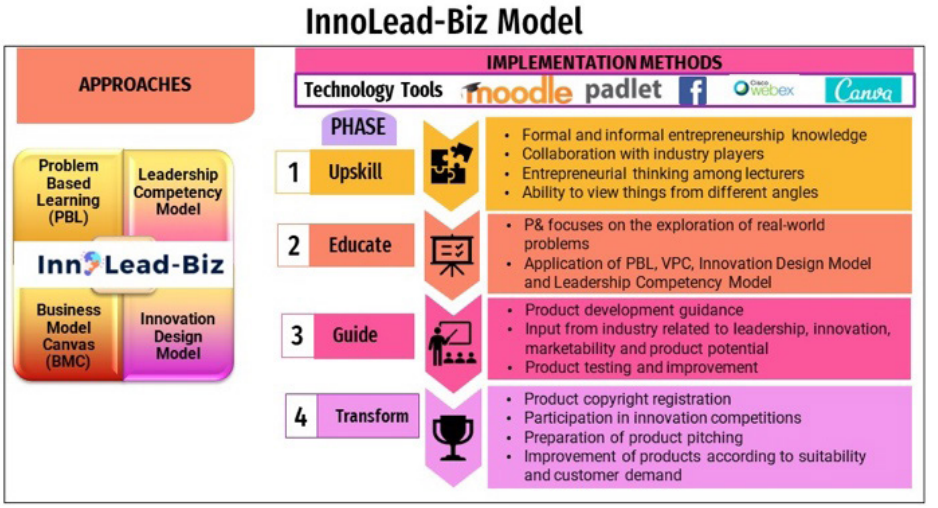


Figure 1 Innolead-Biz Model

tools such as Padlet and discussions in Webex Breakout Rooms. Students are guided to understand the basics of business and the VPC to focus more on producing products that solve user problems. In addition, the Innovation Design Model and Leadership Competency Model are also revealed so that students can plan product production systematically and strategically.

Phase 3: Guide

In addition to guidance from lecturers for product development, students are guided through the input of experts from the industry who are invited to share their innovations and give feedback on the products being developed by students. For small group guidance, lecturers provide consultations using Webex. Students make product improvements based on observations, reflections, and feedback received.

Phase 4: Transform

Students turn into educators who are constantly innovating. They are guided to apply for and obtain copyrights for their developed products and participate in innovation competitions held on Facebook. Pitching videos and digital posters were produced using Canva software due to the lecturer's guidance. Students are also encouraged to improve the products made from time to time.

Finding 2

The project's findings indicate the effectiveness of the teaching and learning model for students of the Innovation in Education course. Throughout the four semesters of teaching the course using the InnoLead-Biz Model, the number of students who scored A- and above showed a positive achievement.

From the quality aspect of innovation products, students have proven that they can apply entrepreneurial thinking skills and exhibit creativity and critical thinking in solving real problems through their innovation products, which are finally translated into medals won in organised innovation competitions. Through this transformative teaching, students successfully secured 13 medals in innovation competitions (4 golds, 5 silvers & 4 bronzes) since this subject was taught in 2020.

In addition to winning medals in innovation competitions, students have registered their innovative products as patents or copyrights. The following is a list of student copyright

Table 1 Innovation in Education Students' Achievement 2020-2022

Grade	Sem 1, 2020/2021	Sem 2, 2020/2021	Sem 1, 2021/2022	Sem 2, 2021/2022
A+	0	1	3	3
A	0	7	8	15
A-	1	2	0	2
B+	2	0	0	3

registers throughout the transformative teaching of InnoLead-Biz – (i) Play and Say, (ii) Victure Vingo, (iii) Wordstock, (iv) Scapture, (v) Arduino Learning Kit, (vi) Teacher Self Help Center and (vii) Quick Learn to Bahasa (QLB).



nnoLead-Biz Module

Conclusion

InnoLead-Biz is a transformative teaching method that integrates a problem-based learning approach such as PBL, VPC, Innovation Design Model, and Leadership Competency Model for teaching the Innovation in Education course. The teaching and learning approach aligns with the 21st Century Teaching & Learning initiative that focuses on enhancing students' creativity, critical thinking, real-world problems and solutions, and active and reflective learning with entrepreneurial and leadership mindset application.

This student-centered teaching approach solves the problems of the conventional teaching approach for the course, which used to be too theoretical, lacking emphasis on real-life applications and industrial engagements; hence, it did not inspire students to produce innovative products driven by customer demand. The detailed process of the InnoLead-Biz Model development is documented in this book (scan QR code).

References

Ministry of Higher Education (2009). Higher education leadership academy: Shaping minds, building leadership. Putrajaya: Ministry of Higher Education.

Osterwalder, A., Pigneur, Y., Papadakos, P., Bernarda, G., Papadakos, T., & Smith, A. (2014). Value proposition design. New Jersey: John Wiley & Sons.

Peterson, C. (2003). Bringing ADDIE to life: Instructional design at its best. *Journal of Educational Multimedia and Hypermedia*, 12(3), 227-241.

Sandoval, W. A., & Bell, P. (2004). Design-based research methods for studying learning in context: Introduction. *Educational Psychologist*, 39(4), 199-201.

Savery, J.R. & Duffy, M.D. (1995). Problem based learning: An instructional model and its constructivist framework. *Educational Technology*, 35(5), 31-38.

The Impacts of Teacher Diversity and Students' Engagement on Students' Academic Performance in Malaysian GLU Universities: A Proposed Quantitative Study

Arman Hj Ahmad[1*], Che Rosmawati Che Mat[1], Hadezah Amit[1], Anis Abd Razak[2], Mohd Juraij Abd Rani[3], Nasution Ismail[1]
[1] Universiti Kuala Lumpur Business School, Malaysia
[2] Universiti Malaysia Terengganu, Malaysia
[3] Universiti Malaysia Perlis, Malaysia
[*] arman@unikl.edu.my

Introduction

The Malaysian higher education landscape is in flux, especially regarding inclusivity and diversity. In recent years, GLU universities in Malaysia have emphasised teacher diversity as one of their strategies for improving educational outcomes and creating a more inclusive learning environment. Teacher diversity is essential to student learning experiences and outcomes (Pepple et al., 2025), especially in diverse societies such as Malaysia.

This research examines the effects of teacher diversity on student academic achievement in Malaysian Government-Linked Universities (GLUs). And in Malaysia, where there's a multicultural mix of people, bringing in a variety of teachers can be a significant asset to improving the quality of education and student achievement. Teacher diversity is about having teachers of different racial, ethnic, gender and cultural backgrounds in an academic setting. In the case of Malaysian GLU universities, the drive for teacher diversity is part of the country's Vision 2020 and later policies, which promote a more inclusive and globalised education. Other research has demonstrated that various teaching staff can improve students' learning experiences, foster critical thinking, and make students better prepared to live in a multicultural world (Gurin et al., 2020; Suri, 2021). Yet, empirical work on this subject is scarce in the context of Malaysia.

There is considerable literature on the general educational benefits of diversity, but little research has directly examined the effects of teacher diversity on students' academic achievement in Malaysian GLU universities. Most of the research is qualitative and provides little understanding of the quantitative relationship between teacher diversity and student outcomes. At the heart of the research question this study seeks to answer is the issue of whether and how teacher diversity in Malaysian GLU universities affects student academic achievement. Grasping this relationship is essential to crafting policies and practices that harness diversity for better educational outcomes. So, this paper attempts to analyse, in a quantitative way, the effects of teacher diversity on student academic achievement inside these institutions.

Research Questions

1. How does teacher diversity influence students' academic performance in Malaysian GLU universities?
2. What mediating factors may explain the relationship between teacher diversity and students' academic performance?
3. How does the impact of teacher diversity vary across different student demographics (e.g., race, gender, socioeconomic status)?

This paper adds to the body of research on diversity in education by offering empirical data from the Malaysian context. Its insights will be helpful to policymakers, school administrators, and scholars who aim to improve student performance by increasing teacher diversity.

Literature Review

Underpinning Theory

Two key conceptual frameworks that can be used to assess and interpret the influences of teacher diversity on student achievement in higher education are Social Identity Theory (SIT) and the Contact Hypothesis. Both theories will be drawn upon to provide the conceptual and theoretical basis for this current investigation and assess the study's idea and theoretical basis. Social Identity Theory (Tajfel Turner, 1979) states that their members' social groups partially define people. In schools, students who identify with their teachers tend to be more motivated and do better academically; in other words, students tend to have a better sense of belonging and motivation to do well if they identify with their teachers. This theory is of interest to this study because it can be applied to examine how students' academic performance might be affected by the diversity of the teaching faculty, particularly racial, ethnic, and gender diversity.

The theory states that when students see themselves represented in the teaching staff (e.g., by race, ethnicity, or gender), they may experience a stronger sense of belonging and identification with the academic institution. This image has the potential to have a positive effect on their engagement and their academic work. Conversely, students might see teachers who share the same social markers as ingroup members, which can result in more positive relationships, increased trust, and respect. In contrast, teachers from other social identities (outgroups) can be perceived as prejudiced, with negative implications for students' engagement and academic performance. Thus, a more representative faculty can mitigate intergroup bias by serving as role models for members of different social identities. This can improve educational outcomes for students who identify with these diverse groups.

In educational contexts, social identity is increasingly recognised as a key factor in recent research. For instance, Ojha et al. (2024) discovered that students who feel more racial and gender diverse among faculty members feel more academically self-efficacious and engaged. Similarly, Adams et al. (2022) showed that women in science, technology, engineering, and mathematics (STEM) do better in school when they have female professors, further highlighting the importance of social identity matching.

The Contact Hypothesis (Allport, 1954) supports this theory, which states that intergroup contact under certain conditions can decrease prejudice and increase mutual understanding, positively affecting academic performance. This theory lends credence to the idea that teacher diversity can benefit student achievement. According to this theory, For contact with diverse teachers to be effective, certain conditions must be met, such as equal status between students and teachers, common goals, the student's academic success, cooperation, and institutional support. Students are better positioned to form positive attitudes towards teachers of different backgrounds when such conditions exist. Added to all this, regular, significant interaction with a variety of teachers can assist students in lowering their prior assumptions or biases. The theory holds that, in turn, this can result in more tolerant attitudes, more positive classroom relationships, and, eventually, better academic achievement. A diverse teaching faculty that positively interacts with students from different backgrounds can create a more inclusive and supportive learning environment. This can enhance students' academic motivation and performance.

Recent studies have shown that the Contact Hypothesis can be applied to education. For instance, Velinov & Hamza-Orlinska (2025) identified that students with regular, positive experiences with teachers from various racial and ethnic backgrounds had less implicit bias and more tremendous academic success. Likewise, Lee and Robinson (2023) showed that organised contact with multiple faculty members in collaborative class settings dramatically increased students' academic achievement and narrowed racial achievement gaps.

Teacher Diversity in Higher Education

Teacher diversity means having educators from different racial, ethnic, gender, and cultural backgrounds. It has been linked to many academic advantages, such as improved student engagement, better critical thinking, and higher levels of cultural understanding (Gurin et al., 2020; Banks, 2021). Diversity in teaching is now widely understood to be a key issue in higher education, especially in diverse societies such as Malaysia. Mixed teaching staff could enrich class discussions with multiple perspectives (Pepple et al., 2025), create welcoming classroom spaces, and serve as role models for students who are members of historically excluded groups (Banks, 2022; Ladson-Billings, 2021).

The Government-Linked Universities (GLUs) in Malaysia

The issue of teacher diversity is especially relevant in Malaysia because of the country's ethnic and cultural diversity. Other research has found that Malaysian students thrive in heterogeneous teaching contexts (Pepple et al., 2025) developing better critical thinking and global competence (Murad et al., 2020); Hamdan et al., 2025)). Diversity and inclusion are hallmarks of Malaysia's higher education system. Earlier studies have shown that teacher diversity at Malaysian universities can enhance academic performance, especially in multicultural environments (Murad et al., 2020; Rahman, 2023).

Government-linked universities (GLUs) in Malaysia are closely linked to government-linked companies (GLCs). They are responsible for developing the nation's human capital, especially in areas critical to Malaysia's economic development. The key GLUs in Malaysia include,

1. Universiti Kuala Lumpur (UniKL): UniKL is a centre of excellence in technical and engineering education, providing a skilled workforce in all industrial sectors.
2. Universiti Teknologi PETRONAS (UTP): Founded by Malaysia's oil and gas conglomerate Petronas, UTP is known for its engineering and technology courses supporting Malaysia's energy industry.
3. Multimedia University (MMU): Originally set up to promote the country's ICT industry, MMU is a pioneer in creative multimedia and information technology education.
4. Universiti Tenaga Nasional (UNITEN): A subsidiary of Tenaga Nasional Berhad (TNB), UNITEN specialises in energy and engineering, serving the country's energy sector.

These universities play a crucial role in Malaysia's higher education and contribute to the diversity of faculty and student bodies, which is essential for fostering an inclusive academic environment.

Teacher Diversity in GLUs

Teacher diversity means having faculty from diverse demographic backgrounds, such as race, ethnicity, gender, and cultural experience. In the context of Malaysian GLUs, teacher

diversity is vital for several reasons, such as demographic diversity, cultural and educational backgrounds, and gender diversity.

The demographic diversity of GLUs also encompasses the racial, ethnic, and gender composition of the professoriate. According to a study by Yaacob et al., (2019) such institutions have actively sought to appoint staff from minority backgrounds who can mirror Malaysia's multicultural character. For instance, UTP and UniKL have staff from around the world, especially in the engineering and technology fields, and that contributes to bringing the world into the classroom. In addition, the greater the variety of cultural and educational backgrounds in the faculty, the better students learn. Research, including that of Bakar et al. (2023), shows that a teaching faculty with diverse backgrounds carries diverse pedagogies that can address the needs of the range of learning styles prevalent among students. For example, MMU has staff with creative arts and technology backgrounds, so students receive a broad-based education.

In GLUs and many other universities in Malaysia, faculty gender diversity is another primary concern. Universities such as UNITEN, UiTM and UTM have promoted gender diversity in traditionally male-populated engineering and technology fields. Not only does this make it a more welcoming place, but it also sets an example for students, inspiring more girls to enter STEM professions.

Impacts of Teacher Diversity on Student Academic Performance

An array of teachers can also help improve students' academic outcomes by serving as role models, creating a sense of belonging, and exposing students to different ways of thinking (Ladson-Billings, 2021). Research has demonstrated that students achieve more in school when they identify with their teachers (Tajfel Turner, 1979; Allport, 1954). Based on Social Identity Theory (Tajfel Turner, 1979), students may be more academically successful when they identify with their teachers. On the one hand, the Contact Hypothesis (Allport, 1954) postulates that positive experiences with teachers from different backgrounds can lead to decreased prejudice and better academic performance (Halabi et al., 2021).

Perhaps the most crucial effect of teacher diversity is that it helps students develop more significant critical thinking and problem-solving abilities. A faculty with a broad spectrum of backgrounds, experiences, and views stimulates students to think critically and critically evaluate different views. A study by Hamdan et al., (2025) found that students at Malaysian universities with a diverse faculty demonstrated higher analytical skills and were better equipped to tackle complex engineering problems. Moreover, teacher diversity also positively affects students' academic engagement. According to Yaacob et al., (2019), students at MMU who interacted with faculty members from various cultural and educational backgrounds reported higher levels of engagement and participation in class. This involvement is essential to academic achievement because it leads to a more meaningful learning of the material.

Concerning the above, diversity among faculty members helps create a sense of belonging and inclusivity among students. For example, a study by Ahmad and Lee (2021) at UniKL found that students who felt that their teachers were racially, ethnically, or gender-representative of them were more likely to feel connected to the university and subsequently achieve better academic results. This feeling of belonging is especially relevant in diverse societies such as Malaysia. Again, empirical historical research has demonstrated a clear link between teacher diversity and students' academic achievement. For example, Bakar et al. (2023) conducted a study at UiTM and found that students taught by a diverse faculty had higher GPAs than those in less diverse environments. The study

concluded that exposure to diverse teaching styles and perspectives enhances students' academic ability.

Other than that, in GLUs, where the goal is to produce globally competent graduates, teacher diversity plays a critical role. Various faculty members bring foreign experience to the classroom to help students prepare for the global world. This is especially true in places such as UTP and MMU, where the academic curriculum is conceived in line with an international model (Mahmood Abdullah, 2022). Then, there is a need for more intersectional analysis that considers how multiple dimensions of diversity (race, gender, nationality, and so forth) combine to affect academic performance. According to a study by Bakar et al. (2023) this might be a more subtle way to interpret the effects of teacher diversity.

Hypotheses

H_1: Teacher diversity positively influences students' academic performance in Malaysian GLU universities.

H_2: Student engagement mediates the relationship between teacher diversity and academic performance.

H_3: The impact of teacher diversity on academic performance is moderated by student demographics such as ethnicity and socioeconomic status.

Proposed Research Framework

The proposed research framework (Figure 1) illustrates the hypothesised relationships between teacher diversity, student engagement, and academic performance. The framework also includes potential moderating variables such as student demographics.

Methodology

This study will employ a cross-sectional survey design to collect quantitative data from students enrolled in Malaysian GLU universities. The study will target students enrolled in GLU universities across Malaysia. Four hundred students will be selected using stratified random sampling to ensure representation across different demographic groups, ensuring diversity in ethnicity, gender, and academic discipline. In contrast, 100 participants (students) from each GLU university will be equally recruited through email invitations, with the survey distributed online. The sample will be stratified based on GLU university, year of study, and ethnicity to ensure a diverse and representative sample.

The survey will have 54 questions assessing teacher diversity, student engagement, and academic achievement. The survey will be derived from validated scales of teacher diversity, student engagement, and academic achievement. Items are scored on a 5-point Likert scale, with higher values reflecting

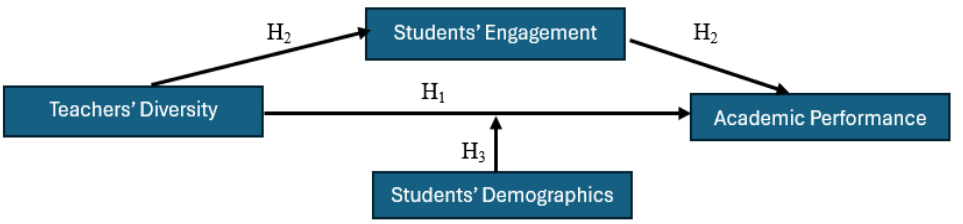


Figure 1 Research Framework

higher perceived diversity, participation, and academic achievement. Teacher Diversity items will be scored on a scale based on an adaptation of Gurin et al. (2020) consisting of 15 items that assess the perceived diversity of teaching staff regarding race, ethnicity, and gender. In addition, Student Engagement will be measured on the National Survey of Student Engagement (NSSE) scale by the Indiana University Centre for Postsecondary Research (1999) (Kuh, 2001; Kuh NSSE Team, 2003), which consists of 22 questions concerning students' participation, student-faculty interaction, and sense of belonging. Academic performance will be assessed by the participants' self-reported GPA and academic satisfaction with 17 items adapted from Pascarella Terenzini (2005).

Data will be collected over a month through an online questionnaire distributed via email and all GLUs' university portals to allow ample duration for data collection and comprehensiveness to generate rich data. All data will be analysed using structural equation modelling (SEM) to examine the proposed relationships. The analysis will include descriptive analysis, normality, and validity tests, as well as mediation and moderation examinations to explore the role of student engagement and demographics in the relationship between teacher diversity and academic performance.

Expected Findings and Discussion

The study is expected to confirm that teacher diversity will positively impact students' academic performance in Malaysian GLU universities. Additionally, it is anticipated that student engagement will mediate this relationship, and it is predicted that the findings will likely suggest that the benefits of teacher diversity are more pronounced for students from underrepresented backgrounds. The findings will likely highlight the importance of teacher diversity in enhancing educational outcomes in multicultural settings like Malaysia. The study will contribute to ongoing discussions about diversity in higher education by providing empirical evidence. Furthermore, the results will contribute to understanding how teacher diversity influences academic performance in multicultural settings like Malaysia. The findings will have implications for university policies on faculty recruitment and development, emphasising the importance of diversity in enhancing students' engagement and academic performance outcomes.

Social identity theory and the contact hypothesis in higher education form a strong education theory that analyses teacher diversity's effects on student outcomes. By identifying and meaningfully interacting with students from different backgrounds, teachers can create a more inclusive environment that facilitates academic achievement for all students.

Conclusion and Suggestions for Future Research

In conclusion, this research underscores the vital importance of teacher diversity in enhancing student academic performance in Malaysian GLU universities. By illustrating the significant connection between diverse teaching faculties and improved educational outcomes, the findings advocate for policies that promote diversity among educators. Addressing issues such as communication barriers and cultural differences will be essential for fostering an inclusive learning environment that benefits all students. By recognizing the critical role of diversity in education, institutions can work towards a more equitable and effective academic landscape.

For future research, longitudinal studies that investigate the long-term effects of teacher diversity on student academic performance are recommended while also exploring additional mediators and moderators such as classroom climate and teaching practices. Furthermore, qualitative studies should be undertaken

to capture students' perceptions of teacher diversity and its impact on their educational experiences. Expanding the research framework to include these factors will provide a more comprehensive understanding of the complexities surrounding teacher diversity and its influence on student outcomes in higher education settings beyond GLU universities.

Acknowledgement

We would also like to thank Universiti Kuala Lumpur Business School and everyone in the impact hub for their endless support and assistance. Finally, to Mak (Hjh. Normah Hashim) and Bak (Hj. Ahmad Akib), may Allah grant both of you with His Jannah. Aamiin Ya Rabb.

References

Adams, M., et al. (2022). The Impact of Gender Representation in STEM Education. *Journal of Educational Psychology*, 114(3), 389-406.

Ahmad, N., & Lee, S. (2021). The Role of Teacher Diversity in Enhancing Students' Sense of Belonging: Evidence from Malaysian Higher Education. *Journal of Educational Research*, 45(3), 211-228.

Allport, G. W. (1954). *The Nature of Prejudice.* Boston: Addison-Wesley.

Banks, J. A. (2021). *Diversity and Citizenship Education: Global Perspectives*. New Jersey: John Wiley & Sons.

Bakar, N. A., Yusop, H., Ali, N. M., & Bakar, N. F. A. (2023). Determinants of students' academic performance in higher learning institutions in Malaysia. I*nternational Journal of Academic Research in Business and Social Sciences, 13*(2), 1496-1508.

Gurin, P., Dey, E., Hurtado, S., & Gurin, G. (2020). Diversity and Higher Education: Theory and Impact on Educational Outcomes. *Harvard Educational Review*, 72(3), 330-366.

Halabi, S., Dovidio, J. F., & Nadler, A. (2021). When intergroup helping helps intergroup relations: The moderating role of trust in the outgroup. *Journal of Experimental Social Psychology*, *95*, 104141.

Hamdan, A., Singh, A. D., & Kovilpillai, J. J. (2025). Navigating the Scholarship of Teaching and Learning in Malaysia and Beyond: A Reflective Journey of Three Practitioners in Higher Education. In *Scholarship of Teaching and Learning (SoTL) in Asian Higher Education* (pp. 197-220). Pennyslavania: IGI Global Scientific Publishing.

Kuh, G. D. (2001). *The National Survey of Student Engagement: Conceptual Framework and Overview of Psychometric Properties*. Indiana: Indiana University Center for Postsecondary Research.

Kuh, G. D., & NSSE Team (2003). *The National Survey of Student Engagement: Conceptual and Empirical Foundations*. Indiana: Indiana University Center for Postsecondary Research.

Ladson-Billings, G. (2021). Culturally Relevant Pedagogy 2.0: a.k.a. the Remix. *Harvard Educational Review*, 84(1), 74-84.

Lee, C., & Robinson, M. (2023). Collaborative Learning and Diversity in Higher Education. *Higher Education Research and Development*, 42(5), 723-740.

Mahmood, F., & Abdullah, M. (2022). Globalisation and Teacher Diversity in Malaysia's GLUs: Challenges and Opportunities. *Journal of Global Education Studies*, 7(1), 89-105.

Murad, M., Ghaffar, A., Mehmood, S., (2020). Impact of Teacher Effectiveness on Students' Engagement at University Level. Global Regional Review, V(III), 238-246. Doi:10.31703/grr.2020(V-III).24

Ojha, V., West, L., & Lewis, C. M. (2024). Computing self-efficacy in undergraduate students: A multi-institutional and intersectional analysis. Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1 (pp. 993-999).

Pascarella, E. T., & Terenzini, P. T. (2005). *How College Affects Students: A Third Decade of Research*. New -Jersey: Jossey-Bass.

Pepple, D. G., Akaighe, G. O., Sambo, A., George-Aremu, O., Bosah, G., & Trollman, H. (2025). Using guest lectures to enhance student employability: pedagogical considerations. *Cogent Education, 12*(1), 2452076.

Tajfel, H., & Turner, J. C. (1979). An Integrative Theory of Intergroup Conflict. In W. G. Austin & S. Worchel (eds.), *The Social Psychology of Intergroup Relations* (pp. 33-47). Pacific Grove, California: Brooks/Cole Publishing.

Tan, J., & Rajah, V. (2023). Communication Barriers in Multicultural Teaching: Challenges in Malaysian GLUs. *Journal of Communication and Education*, *35*(4), 299-318.

Velinov, E., & Hamza-Orlinska, A. (2025). Teaching global diversity, equity and inclusion through the lenses of queer theory. In Ã–zbilgin, M. F. & Erbil, C. *Research* Handbook on Global Diversity Management (pp. 331-345). Cheltenham, London: Edward Elgar Publishing.

Yaacob, A., Awang-Hashim, R., Valdez, N. P., & Yusof, N. (2019). Illuminating diversity practices in Malaysian higher education institutions. Asia Pacific *Journal of Educators and Education, 34*, 1-16.

Leveraging Peer Teaching to Enhance Conceptual Understanding in Statics and Dynamics for a First-Year Student Experience

Mazlin Idress*, Mazuin Jasamai
Universiti Teknologi PETRONAS, Malaysia
*mazlinidress@utp.edu.my

Introduction

Statics and dynamics are foundational subjects in engineering education, providing students with essential knowledge about forces, equilibrium, and motion. Mastering these subjects can be particularly challenging for first-year university students due to the abstract nature of the concepts, the mathematical rigour involved, and the need for spatial visualization skills. Traditional instructional methods often fall short of addressing the diverse learning needs of students, leading to gaps in understanding. Peer teaching is a promising pedagogical strategy to bridge these gaps and enhance students' learning outcomes. This paper explores how peer teaching, applied within the framework of statistics and dynamics, can significantly improve conceptual understanding, student engagement, and knowledge retention.

Peer teaching is grounded in students learning by teaching one another. Vygotsky's Social Development Theory (Vygotsky, 1978) emphasizes the importance of social interactions in cognitive development. His concept of the Zone of Proximal Development (ZPD) suggests that learners perform best when guided by someone slightly more advanced than themselves. In peer teaching, students often work within their ZPD by providing and receiving guidance, allowing them to consolidate and extend their learning. This dynamic is crucial in peer teaching, as it allows both the "tutor" and "tutee" to grow intellectually through collaborative learning.

Similarly, Bandura's Social Learning Theory (Bandura, 1977) suggests that people learn through observing others, imitating behaviours, and receiving feedback. Peer teaching aligns with this theory, involving students teaching and learning through interaction. Bandura's theory supports that teaching enhances students' understanding and mastery of the material, as they must organize and articulate their knowledge for others. Constructivist Learning Theory, championed by Piaget and Dewey (1972), further supports peer teaching. It argues that learners construct knowledge actively, emphasizing dialogue and problem-solving. Peer teaching offers an excellent platform for this constructivist approach, as students collaborate, share perspectives, and solve problems collaboratively. Jigsaw activities, part of structured peer teaching sessions, align closely with Cooperative Learning Theory, developed by Johnson and Johnson (2008), emphasizing positive interdependence, individual accountability, and collaborative efforts. In a jigsaw, each student contributes a crucial part of the learning puzzle, and the group's success depends on everyone's involvement and contribution. This cooperative structure enhances both individual and group learning outcomes.

The theories leverage the idea that students may better relate to their peers' explanations, fostering a collaborative environment where students actively participate in their learning process. Students also consolidate their understanding of the subject by teaching their peers reinforcing key concepts. Studies have shown that peer teaching can improve comprehension, confidence, and communication skills. Statics and dynamics, being highly visual and mathematical, offer unique opportunities for peer teaching. These subjects require students to understand how forces interact in structures (statics) and how those forces influence motion (dynamics). Through peer-led discussions, group problem-solving, and teaching activities, students can clarify complex concepts, explore alternative problem-solving techniques, and develop a deeper, more intuitive grasp of the subject matter. This paper describes a peer-teaching initiative implemented for first-year students in a university engineering program, highlighting its design, execution, and outcomes.

The primary objective of this initiative was to enhance students' conceptual understanding of statics and dynamics through peer teaching. The specific goals were to increase student engagement and participation in class activities. Peer teaching also fosters collaborative learning environments that allow students to approach problems from different perspectives and encourage them to explain and teach core concepts, strengthening their understanding. This method also provides a platform for students to practice problem-solving techniques in a less formal, peer-supported setting.

Methodology

Implementation of Peer teaching in the statistics and dynamics course followed this approach.

Selection of Peer Teachers

A group of students who demonstrated a firm grasp of the material early in the semester were invited to participate as peer teachers. These students were provided additional training on effective teaching strategies, communication skills, and collaborative learning techniques.

Structuring of Peer Teaching Sessions

Peer teaching was integrated into the course through a series of structured sessions. These sessions were held in small groups to promote active participation and discussion. Peer teachers would introduce a concept, followed by collaborative problem-solving or Jigsaw activities where students worked together to apply the idea to real-world engineering problems.

Activity Design

Each peer teaching session focused on a specific concept or set of problems in statistics and dynamics. Activities included diagramming forces, solving equilibrium equations, and visualizing kinematic and kinetic scenarios. Peer teachers encouraged group discussions, guided students through problem-solving steps, and asked probing questions to stimulate critical thinking.

Assessment and Feedback

Formative assessments were used throughout the peer teaching sessions to gauge students' understanding. Peer teachers and students provided feedback on the sessions to improve the learning experience continually. Students also participated in reflection exercises, analysing their learning progress and the effectiveness of peer teaching.

Final Evaluation

At the end of the semester, students were assessed through traditional exams and project-based evaluations. The exam results were compared with previous cohorts who did not participate in peer teaching to evaluate its impact on learning outcomes.

Results and Discussion

Improved Conceptual Understanding

Students who participated in peer teaching demonstrated a firmer grasp of fundamental concepts in statistics and dynamics. This was evident in their ability to solve complex problems, explain key concepts to their peers, and confidently approach new problems. Students who struggled initially reported that the peer teaching sessions helped clarify complex concepts and gave them new problem-solving strategies.

Increased Engagement

Peer teaching created a more interactive and engaging learning environment. Students were more likely to participate in discussions, ask questions, and share their thoughts during peer-led sessions than in traditional lectures. The collaborative nature of the sessions also fostered a sense of community among students, contributing to a more positive learning experience.

Enhanced Problem-Solving Skill

Peer teaching emphasized the correct answer and the process of arriving at the answer. Students learned to approach problems systematically, apply core principles effectively, and consider multiple solutions. This process-oriented approach helped students better understand statistics and dynamics and improved their ability to tackle new and unfamiliar problems.

Positive Feedback from Students

Student feedback on the peer teaching initiative was overwhelmingly positive. Many students appreciated the opportunity to learn from their peers, as the informal setting made them feel more comfortable asking questions and admitting when they did not understand something. Peer teachers also found the experience rewarding, as teaching helped solidify their understanding and boosted their confidence.

Higher Academic Performance

The final exam results showed that students who participated in peer teaching outperformed those from previous cohorts who did not benefit from peer-led sessions. There was a noticeable improvement in their conceptual understanding and ability to apply concepts to real-world engineering problems.

The success of this peer teaching initiative highlights the effectiveness of collaborative learning in complex subjects like statistics and dynamics. One of the key benefits of peer teaching is that it allows students to learn in a low-pressure environment, where they can openly discuss their challenges and work through problems together. This is particularly important for first-year students, who may feel intimidated by the complexity of engineering subjects and hesitant to ask questions in large lecture settings.

Peer teaching also encourages metacognitive skills, as students must understand the material and think about how to explain it to others. This deepens their comprehension and helps them retain information over the long term. Additionally, the experience of teaching peers builds essential soft skills, such as communication, teamwork, and leadership, which are crucial for future engineers.

Conclusion

Peer teaching is a powerful pedagogical tool that can significantly enhance students' understanding of statistics and dynamics in their first year of university. By fostering a collaborative learning environment and encouraging students to take an active role in their education, peer teaching helps students build confidence, improve problem-solving skills, and achieve higher academic outcomes. This initiative demonstrates the potential of peer teaching to transform the learning experience for engineering students. It provides a model for other educators looking to implement similar strategies in their classrooms.

Future research could explore the long-term impact of peer teaching on students' academic performance and professional development, as well as investigate the scalability of this approach for larger cohorts and more diverse subject areas.

References

Bandura, A. (1977). *Social Learning Theory*. Eaglewood Cliffs: Prentice Hall.

Dewey, J. (1938). *Experience and Education*. London: Macmillan.

Johnson, D. W., & Johnson, R. T. (2008). *Cooperation and competition: Theory and research*. Massachusetts: Interaction Book Company.

Piaget, J. (1972). *Psychology and Pedagogy*. Viking Press.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard: Harvard University Press.

Empowering Microprocessor Students to Attain Knowledge and Skills Using 32-Bit Arm Processor Kits through Practical Task and Project Undertakings

Mohd Zuki Yusoff
Universiti Teknologi PETRONAS, Malaysia
mzuki_yusoff@utp.edu.my

Introduction

Microprocessors are fundamental in modern engineering education, yet traditional teaching methods often struggle to connect effectively theoretical concepts with practical skills. This course integrates ARM Cortex M4-based Nucleo F411 boards into a twelve-week curriculum to address the gap. The course incorporates transformative teaching practices, immersive technologies and student-centred learning to enhance engagement, critical thinking, and technical skills. The approach is designed to give students a comprehensive understanding of microprocessors through lectures, lab work, practical tasks, and project-based assignments.

Background

Microprocessors are critical to modern engineering systems, yet traditional pedagogical approaches often fail to bridge the gap between theoretical concepts and practical application. This disconnect is particularly evident in curricula that rely on outdated architectures rather than some of the prevalently utilised industry-standard 32-bit ARM processors (Freeman et al., 2014).

Active learning methodologies, such as project-based tasks and hands-on experimentation, have proven effective in addressing this challenge. Freeman et al. (2014) demonstrated that students in active learning environments outperform peers in passive lecture settings, especially in STEM fields. Laurillard's Teaching as a Design Science (2013) further emphasises the importance of iterative, student-centered activities (e.g., coding, debugging, hardware interfacing) to deepen conceptual understanding.

The integration of ARM Cortex-M4 processors (via Nucleo F411 boards) aligns with Mayer's (2009) principles of multimedia learning, which advocate for combining visual, auditory, and kinesthetic modalities to enhance retention of complex technical concepts. This approach ensures students engage with tools reflective of real-world embedded systems development.

Moreover, recent trends in embedded systems education advocate for the use of contemporary, industry-relevant hardware such as ARM Cortex-M series microcontrollers. The Nucleo F411RE board, in particular, offers robust capabilities for exploring peripheral interfacing, memory management, and interrupts — critical areas for developing expertise in embedded system design (STMicroelectronics, 2022).

Methodology

The course is organised into three main components — theoretical instruction, practical tasks and project work.

Theoretical Instruction (Weeks 1-5)

Week 1: Introduction to microprocessor operation and architecture (LO 1; Topic 1)
Week 2: Hardware interfacing concepts (LO 2; Topic 2)
Note that LO 1 and LO 2 assessments involve two written tests covering theoretical knowledge (28% of the final grade: Test 1 (LO 1) - 14%, Test 2 (LO 2) - 14%).
Week 3: Assembly language programming for ARM processors (LO 3; Topic 3)
Week 4: Embedded programming in C/C++ (LO 3; Topic 3)
Week 5: Exception handling and interrupts (LO 4; Topic 4)
Note that the lectures and lab sessions during Weeks 1 to 5 provide foundational knowledge and prepare students for practical applications in the remaining seven weeks of the semester.

Practical Tasks (Weeks 6-9)

Practical Task #1 (Weeks 6-7): Students work in groups to solve input and output manipulation problems using assembly language on the Nucleo F411 board. Demonstrations and group reports are required for assessment (20% of the final grade)..

Practical Task #2 (Weeks 8-9): Students address similar problems using C/C++ on the same board. The outcomes are demonstrated through code and reports (20% of the final grade).

Project Work (Weeks 10-12)

Students proposed and developed a project using the Nucleo board, focusing on hardware design (LO 1 and LO 2 assessments), firmware, and software development (LO 3 and LO 4 assessments). The project is evaluated on background research (LO 1 assessment), hardware design (LO 2 assessment), firmware/ software development (LO 3 and LO 4 assessments) and overall outcomes. Here, students present their projects and submit a group report (32% of the final grade).

Results and Discussion

Initial results indicate that students benefit significantly from the hands-on experience provided by the 32-bit processor kits. Enhanced engagement, problem-solving skills, and a deeper understanding of microprocessor concepts have been reported. Integrating practical tasks and project work has effectively linked theoretical knowledge with practical application, leading to more comprehensive learning outcomes.

The course demonstrates the effectiveness of integrating 32-bit processor kits into microprocessor education. By combining transformative teaching methods with immersive technologies and a student-centred approach, the course provides a robust learning experience. The hands-on tasks and project-based assignments bridge the gap between theory and practice, preparing students for real-world engineering challenges.

Conclusion and Future Work

The innovative approach outlined in this course effectively enhances students' understanding and skills in microprocessors. Future course iterations could benefit from incorporating additional immersive technologies and expanding project opportunities to enrich the learning experience further. Ongoing evaluation and refinement of the course structure will ensure continued relevance and effectiveness in engineering education.

References

Freeman, S., Eddy, S. L., McDonough, M, …, Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410–8415. Doi:10.1073/pnas.1319030111

Laurillard, D. (2013). *Teaching as a design science: Building pedagogical patterns for learning and technology*. Oxfordshire: Routledge.

Mayer, R. E. (2009). *Multimedia learning*. Second Edittion. Cambridge University Press.

STMicroelectronics. (2022). *Nucleo F411RE user manual*. STMicroelectronics. https://www.st.com/resource/en/user_manual/um1724-stm32-nucleo64-boards-mb1136-stmicroelectronics.pdf

Integrating Virtual Reality to Enhance Petroleum Engineering Education: A Case Study in Drilling Engineering

Muhammad Aslam Md Yusof*, Nurrul Hazwani Abu Bakar
Universiti Teknologi PETRONAS, Malaysia
*aslam.myusof@utp.edu.my

Introduction

Problem-solving is fundamental to petroleum engineering education, enabling students to grasp complex theoretical concepts through practical application. However, the traditional method of teaching petroleum engineering, which relies heavily on theory-based instruction, has diminished comprehension, motivation, and student engagement. Consequently, this has led to increased failure rates and drop-outs, a trend observed particularly in petroleum engineering courses.

Although regarded as the second most advanced after aerospace engineering, Petroleum Engineering still relies on traditional content delivery methods (Aggour, Donohue, & Donohue, 2015; Ismail, Yusof, & Herman, 2017). Less effort has been made into teaching innovations, leading to an initiative by the Society of Petroleum Engineers (SPE) to create an annual teaching innovation award in the discipline (Jacobs, Betz, & Rassenfoss, 2015). As one of the core principles in petroleum engineering, drilling engineering covers the fundamentals of drilling equipment, engineering calculations of well engineering, and the complete life cycle of typical drilling operations.

In response to this need, advanced learning tools such as 3-dimensions (3D) virtual learning environments have been introduced, offering an immersive and interactive means of engaging students. These digital tools, which combine visual and auditory elements, have proven effective in making complex engineering concepts more accessible to students increasingly accustomed to digital and interactive content. This paper explores the effectiveness of integrating Virtual Reality (VR) applications into the teaching of the Drilling Engineering II course (PEB2073) for third-year petroleum engineering students at Universiti Teknologi Petronas (UTP).

This paper evaluates the effectiveness of incorporating VR as a supplementary teaching tool in the Drilling Engineering II course for petroleum engineering students at UTP. Specifically, the study aims to assess whether VR technology enhances student comprehension of complex drilling equipment and processes, improves overall academic performance, and helps achieve the intended course outcomes by bridging the gap between theoretical knowledge and practical application.

Methodology

This study involved 150 third-year petroleum engineering students enrolled in the Drilling Engineering II (PEB2073) course at UTP. The objective was to assess the impact of VR technology on enhancing student understanding of drilling equipment, systems, and processes.

VR Module Development

The VR module was designed to simulate a 3D interactive tour of different types of drilling rigs, their components, and the overall drilling processes. The module was structured to cover key topics from the course, including a detailed exploration of drilling equipment, operational systems, and typical workflows encountered in the drilling industry.

Student Engagement with VR

Each student was allotted 30 to 45 minutes to explore the 3D VR module. During this time, they could navigate through the virtual rig, examine its various systems, and interact with different components to gain a deeper understanding of their functions. The immersive nature of the VR experience allowed students to engage with complex engineering concepts at their own pace, promoting individualised learning.

Assessment through Quizzes

At the end of the VR session, each student was required to complete a quiz to assess their understanding of the material covered during the virtual tour. The quiz included multiple-choice and short-answer questions that tested knowledge of drilling equipment, engineering calculations, and the life cycle of typical drilling operations. Students' performance on these quizzes was analysed to determine the effectiveness of the VR experience in reinforcing theoretical concepts.

Feedback Collection and Analysis

In addition to the quizzes, students were asked to provide feedback on their experience with the VR module. The feedback questionnaire covered areas such as:

a. The clarity of the 3D simulations
b. The ease of navigation and interaction within the virtual environment
c. The perceived effectiveness of the VR module in enhancing their understanding of the subject matter
d. Suggestions for further improvements to the learning tool

The collected feedback was systematically analysed to evaluate the overall student response to the VR application. Quantitative data from quiz scores and qualitative feedback from students were used to conclude the success of the VR intervention in improving comprehension and engagement.

Comparison with Previous Student Performance
The quiz results and overall course performance of the 150 students who experienced the VR module were compared with historical data from previous cohorts who were taught using traditional methods without VR in comparing the impact of VR on the learning outcomes. This comparison allowed the study to measure improvements in student performance, comprehension, and engagement concerning introducing VR technology into the curriculum. By integrating VR as part of the course, the study aimed to bridge the gap between theoretical knowledge and practical application, providing insights into the potential of immersive learning technologies to improve educational outcomes in petroleum engineering.

Results & Discussion

Analysis of Students' Performance

Integrating VR into the Drilling Engineering II course notably impacted student performance. The average score on the post-VR quizzes increased significantly compared to the results from previous cohorts who did not have access to the VR module. Specifically, the average quiz score for the 150 students was 75%, compared to 60% from previous years without VR.

A deeper analysis of quiz results showed that students performed exceptionally well on questions related to understanding the functions of drilling equipment and the step-by-step processes involved in drilling operations. For example, 85% of students correctly answered questions about the functions of specific drilling components, compared to 65% in previous cohorts. This suggests that VR's interactive and immersive nature helped students better visualise and retain key concepts.

Student feedback revealed high levels of engagement and motivation during the VR sessions. Of the 150 students, 92% reported that the VR experience made learning more engaging and enjoyable. Many students noted that being able to virtually "walk through" the drilling rig helped them better understand its complex systems and processes. They appreciated the self-paced learning environment, allowing them to revisit difficult concepts until they felt comfortable understanding.

The visual and auditory elements of the VR module were particularly well-received, with 89% of students agreeing that the 3D simulations made complex concepts more digestible. Additionally, the interactive nature of the tool, which allowed students to explore the drilling rig hands-on, was highlighted as a key factor in improving comprehension. This feedback aligns with research that shows digital-native students respond positively to interactive learning environments.

Feedback on VR Effectiveness

A thematic analysis of the feedback indicated that students valued the clarity and realism of the VR simulations. 80% of respondents mentioned that the ability to interact with and explore different parts of the rig helped them connect theoretical knowledge with real-world applications. Some students suggested improvements such as adding more detailed scenarios or expanding the range of equipment that could be explored in the VR environment. Despite the overwhelmingly positive feedback, a small percentage of students (8%) expressed minor concerns, mainly related to feeling overwhelmed by the amount of information presented in the virtual environment. These students suggested that further scaffolding the material or breaking the VR experience into smaller, more manageable segments might enhance its effectiveness for learners less comfortable with virtual environments.



Figure 1 Analysis of students' feedback for the VR activity

Conclusion

The integration of VR in Drilling Engineering II significantly improved student comprehension, performance, and engagement. By offering immersive, interactive learning, VR helped

bridge the gap between theoretical knowledge and practical application, reducing failure rates and enhancing learning outcomes. VR demonstrates excellent potential as a valuable tool in petroleum engineering education.

Acknowledgement

Special thanks to the Petroleum Engineering Department for supporting this research work.

References

Aggour, T., Donohue, T., & Donohue, D. (2015). Modernizing Petroleum Engineering Education: A New Global Online Petroleum Engineering University Serving all Universities. Paper presented at the SPE Annual Technical Conference and Exhibition.

Jacobs, T., Betz, J., & Rassenfoss, S. (2015). E&P Notes *Journal of Petroleum Technology*, 67(04), 40-43.

Development of Storyboard for an Interactive 360 Virtual Reality Tour of A Combined Cycle Power Plant for an Engineering Course - Process Heat Transfer

Wan Zaireen Nisa Yahyaa*, Shafirah Samsuria, Pai Jun Jiea
Universiti Teknologi PETRONAS, Malaysia
*zaireen.yahya@utp.edu.my

Introduction

Process Heat Transfer is a core chemical engineering course that is designed to equip students with the fundamentals of process heat transfer, namely the physical principles underlying heat flow by conduction, convection, and radiation mechanisms, as well as solving problems relevant to the design of chemical engineering systems, especially heat exchangers. The students are given theoretical knowledge of heat transfer equipment such as boilers, condensers, and heat exchangers. One of the problems when explaining the heat transfer processes in the industry is visualising and understanding the heat transfer equipment and processes in an actual industrial plant. To visualise this equipment, videos and images are usually shared in class to show examples of the applications of this equipment in the industry. To solve this problem, many educators resorted to field trips to chemical plants. However, visiting chemical plants is not always possible due to safety restrictions, high travel costs, administration procedures, etc. Moreover, even by visiting existing chemical plants, the explanation given during the tour may not be well delivered and effective due to the students' noise, retention, attention and other external factors.

Virtual technology provides the possibility to experience lifelike simulations and virtual explorations of location/equipment/environment/time, which are sometimes not accessible to everyone due to location, safety, cost, and many other external factors. Virtual reality (VR) can be best described as a digital representation of a three-dimensional object and environment. VR has been widely adopted in training, education, and commercial settings to create immersive and interactive experiences for the user. VR technology allows students to explore on their own and make meaningful learning experiences, as when students are immersed in what they are learning, this will motivate them to understand and comprehend the knowledge fully (Alhalabi, 2016; Ghazali et al., 2024).

VR application in engineering education allows for enhanced learning experiences across various disciplines within the field (Retnanto, 2019; Marougkas, 2021). Some examples are virtual laboratory, engineering design and prototyping, simulation of real-world scenarios, training for hazardous environments, field trips and site visits, collaborative design and collaboration, soft skills development, etc. Redel-Macias et al. (2016) have developed a virtual laboratory that includes simulations, video tutorials, exercises, and questionnaires to substitute actual laboratory practices for the subject of biomass for power generation. The study shows that VR learning can provide similar learning achievements. Vlah et al. (2021) developed an interesting work on using VR as an immersive 3D modelling tool

in engineering design applications. The VR platform allows the students to conceptualise, prototype, and iterate engineering designs in a virtual environment. The study found that when comparing VR modelling to desktop modelling, VR offers users better spatial perception and visualisation but lacks precision in the created 3-dimension (3D) models.

Colombo et al. (2012) studied immersive virtual reality (IVR) for training and decision-making for field and control-room operators, performed with a plant simulator for oil and gas facilities. Their VR module allows them to simulate hazardous environments (hot work in the presence of flammables) where learners can safely learn and practice maintenance, repair, and emergency response procedures. This application enhances safety training and prepares learners without exposing them to risk. They found the participants who had undergone the VR simulation training performed comparatively better in the practical assessment than those who had gone through the slide-supported training containing 3D images.

In another example of engineering education, Wu et al. (2022) designed a virtual reality plant of dimethyl ether production process to aid students in improving their skills. The developed virtual system has embedded an integrated process control system and virtual scene simulation to replace on-site training and improve practical skills. The VR-integrated platform has been demonstrated to improve the student's knowledge of chemical equipment and operating procedures more than that of chemical production theory. These applications demonstrate the versatility and potential of VR in enhancing engineering education, offering innovative solutions to traditional challenges, and preparing students for the demands of a rapidly evolving engineering landscape. Norton et al. (2008) mentioned that undergraduate chemical engineering students generally have good theoretical knowledge but often cannot visualise the scale and complexity of actual process plants, while process operators lack a theoretical understanding of the principle behind the processes. Hence, the VR suits students and operators, offering visual explanations rather than traditional text-based learning.

However, despite its promising potential, integrating VR into engineering education has challenges. Among the main challenges of VR, besides the facilities and cost, are making the learning engaging, creating immersive learning, and improving the student's understanding of complex engineering concepts. As educators and institutions strive to leverage VR to enrich the learning experiences of engineering students, it is imperative to address these challenges effectively to unlock the full potential of this innovative technology and ensure its successful integration into engineering curricula.

Some challenges/questions posed when developing new learning content/tools/ methods:

1. How do we create descriptive and interactive virtual reality modules for technical equipment?
2. Can we integrate virtual visits and complex engineering problem-solving skills in the VR content?
3. Can adopting VR technology improve students' comprehension of heat transfer equipment and processes?
4. What is the impact of implementing VR modules on students' performance?
5. What is the impact of implementing VR modules on learning experiences?

The main aim of this study is to develop an interactive virtual reality module on heat transfer equipment in a power plant, which can enhance the learning experience and understanding of complex engineering equipment. In this paper, the storyboard is used to help visualise the content by outlining the scenes and sequences to facilitate the process of the VR module creation. Storyboards are essential for visual storytelling, serving as blueprints for the narrative, helping

with organisation, and highlighting key visual elements. It is aimed that this study will provide insights into the opportunities and obstacles associated with integrating VR into engineering education, offering recommendations and strategies to optimise its use and maximise its impact on student learning and development.

Research Methodology

Process Flow of the VR Module Development and Implementation

The Process Flow of the VR Module development is shown in Figure 1, with further description below.

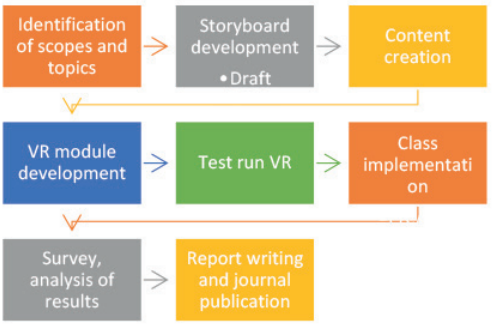


Figure 1 Process Flow of the VR development and implementation

Identification of Topics and Scopes

Name of Course: CFB1063-Process Heat Transfer (Chemical Engineering Undergraduate, First-year 3rd Semester)

Course synopsis: This course is a required component of the Body of Knowledge (BoK) in the Chemical Engineering profession. It is designed to equip students with the fundamentals of process heat transfer. This course will help students face challenges in developing new processes, equipment, and operations. Emphasis will be given on the physical principles underlying heat flow by conduction, convection, and radiation mechanisms. Applying this knowledge can solve problems relevant to the design of chemical engineering systems, especially heat exchangers. It will also help to develop essential problem-solving and critical-thinking skills.

Course learning outcomes (CLO):
CLO1: To analyse and estimate the heat transfer rate by conduction, convection, and radiation in the systems of practical interest.
CLO2: To evaluate the heat transfer rate during boiling and condensation phenomena.
CLO3: To design and evaluate the performance of heat exchanger devices.

Case study chosen: Heat Recovery Steam Generator (HRSG) in a combined cycle power plant.

Topics relevant for VR module development: Boiling heat transfer, heat exchanger (CLO2 and CLO3)

VR module Lesson Learning Outcomes (LO):
LO1: To illustrate the heat transfer principle and processes in heat exchanger equipment in a combined cycle power plant.

Storyboard development

1. Samples of the storyboard are presented in the Results and Discussion
2. The storyboard is used to facilitate the developer for the VR module development

Content creation and VR module development

1. 360 images of a Combined Cycle Power Plant (Plant visit in Lumut Power Plant).
2. 3D models of the power plant and HRSG equipment and images.
3. Videos from the internet and other educational resources were used as references to create the content.

Classroom implementation (next step)

1. Pre-class surveys
2. Post-class surveys
3. Performance analysis pre-class and post-class

Project Assessment Plan (next step)

The effectiveness of the action research interventions will be assessed, i.e., pre-test/ post-test, student-lecturer reflections,

1. Pre-quiz
2. Non-graded quiz during VR
3. Post-quiz
4. Pre and post-survey
5. Student lecturer reflection

Result and Discussions

Developing Virtual Reality (VR) content for engineering education requires thoughtful consideration of narrative structure and interactivity. Unlike traditional media, VR offers an immersive and engaging environment where the user is not just a passive viewer but an active participant in the story. As such, the storyboard development is essential for planning and structuring the module's content. A storyboard comprised an overview of the module (Figure 2) and the page structure of the scenes. A good storyboard will be as detailed as possible to simplify the designer to create content as intended.

In creating the immersive content, the following steps are taken into consideration based on principles of instructional design of educational multimedia (Norton et al., 2008):

1. Interactive: Allows users to explore and interact with the environment in a first-person storytelling form to personalise the learning. Experiences are more manageable when structured into knowledge networks.

2. User-Centered Storytelling: use a branching storyline, and the narrative should prompt the user to act. The users must also move to the following location once they've explored.

3. 3. Pacing and flow: By balancing the narrative's pacing with the learning experience, the users have enough time to absorb the material without being too slow, which may lead to disengagement.

4. Multiple representation principle: Combining words and pictures for users to exercise visual and verbal channels.

Storyboard Overview				
Lecturer	Dr Wan Zaireen Nisa Yahya		**Department**	Chemical Engineering
Module name	Process Heat Transfer		**Module duration**	3-5 minutes
Storyboard version	Draft 1			
Project goal/success measurements	For students to recognize the different heat transfer equipment in a power plant and understand their working principles.			
Topics to be covered	**1**	Overview of Combined Cycle Power Plant		
	2	Heat Exchanger: Heat Recovery Steam Generator		
	3			
Development tool	Virtual Reality (VR)			

Figure 2 Storyboard overview of the VR module

5. Contiguity principle: Words and pictures to be presented simultaneously rather than sequentially.

6. Coherence principle: Use pertinent words and text simplification without unnecessary facts and sounds to avoid distraction and ease the learners' processing of information.

7. Redundancy principle: To limit to a maximum of two sources of information, i.e., animation + narration and not animation + narration + on-screen text.

Figure 3 shows an example of the module's opening page. The students will be given a choice of 3 sets of modules they can navigate. The modules are also connected and can be followed preferentially in sequence. The VR world has been developed so that users can see 360-degree images of an actual power plant and experience a similar plant tour with narration.

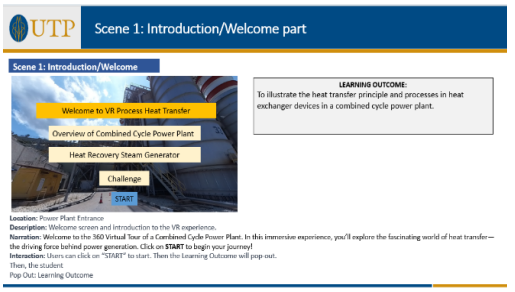


Figure 3 Opening page of the module

Figure 4 shows the content of the first module, which provides an overview of the combined cycle power plant. As the content is descriptive, a video narration of the function of different plant components is given.

The second module on the Heat Recovery Steam Generator describes the heat transfer equipment, including the principles of the heat transfer processes. Here, the modules are divided into several sections, and the users can navigate to different frames within the module by clicking the next or back button (Figure 5).

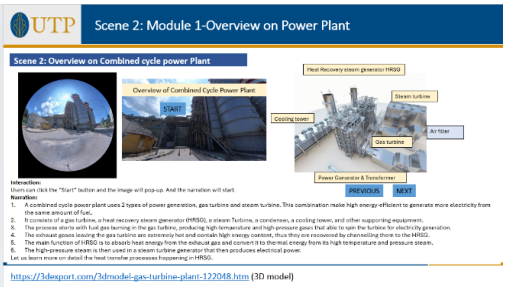


Figure 4 Scene of Module 1-Overview on Power plant



Figure 5 Different frames in the same module HRSG

To ensure the educational objectives are attained, the VR module includes built-in assessments accessible in the Module Challenge. The students are given sets of questions (Multiple Choice Questions) to test their understanding based on the learning modules that they have gone through. There are

20 sets of questions that are randomised for the students to answer. Some samples are given in Figure 6. The questions are designed to align with the intended learning outcome, illustrating the heat transfer principle and processes in heat exchanger equipment in a combined cycle power plant.



Figure 6: Sets of questions in the Challenge Module

Once the storyboard is completed, the next phase is the VR content development. Continuous feedback between developers and the course instructor is required. The VR content can then be tested with the target audience, and feedback on the content can be obtained. Elements that seem clear to developers may not resonate with learners. Gathering feedback on how engaging the narrative is, whether users felt they were learning, and if they understood how to interact with the environment are among the essential elements. Testing also allows us to adjust the pacing, difficulty, and level of interactivity based on user feedback, ensuring the story is educational and immersive. Lastly, the effectiveness of the VR module can be evaluated in terms of students' performance pre and post-VR implementation in class.

As part of the storyboard development phase, visiting the actual plant to obtain the 360 images gives students a real-life experience. It is essential during the visit to capture good images and videos to later work on the Virtual content production. One of the disadvantages of 360 images is the lack of interactivity and 2-dimension (2D) static pictures. 2D static pictures are essential when developing an overlay of 3D images or animation.

Before the full development of the VR, a batch of students was brought to the actual power plant. Before they tour around the plant, the technical trainer and plant manager explained the whole process of power generation in the amphitheatre. Unfortunately, during the visit, for safety reasons, the students visited the process area from inside a bus as the plant was on the run. Feedback was gained from the students to gain insight into the learning experience. The following feedbacks were obtained:



Figure 7 Feedback survey from students post-field trip

cont.

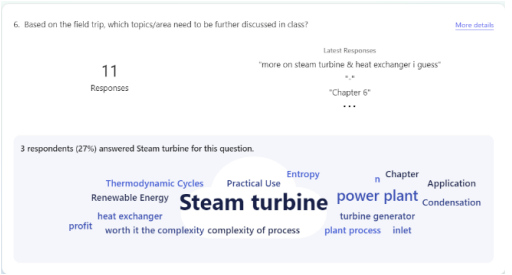


Figure 7 Feedback survey from students post-field trip

Based on the feedback, it is essential to note that virtual reality can be as complementary to learning as some knowledge can still not be learned during authentic field trips. The VR module should then be developed with contents that could not be obtained during the field trip.

Conclusion

Storyboard development for VR in engineering education requires more than just a linear narrative; it requires creating an immersive, interactive experience that places the learner at the story's centre. Designing a virtual world that is intuitive and rich in educational content and interactive while ensuring the pacing that supports learning enables an engaging and practical educational VR experience. Hence, storyboard development is essential in creating a VR module supported by continuous improvement and feedback from different perspectives and stakeholders.

Acknowledgement

The authors gratefully acknowledged financial support from the Scholarship of Teaching and Learning (SOTL) grant from Universiti Teknologi Petronas (UTP), Chair of Chemical Engineering Department, Centre of Academic Excellence (CADEX), for continuous support.

References

Alhalabi, W. (2016). Virtual reality systems enhance students' achievements in engineering education. *Behaviour & Information Technology*, *35*(11), 919-925.

Colombo, S., Nazir, S., & Manca, D. (2014). Immersive virtual reality for training and decision making: preliminary results of experiments performed with a plant simulator. *SPE Economics & Management*, *6*(04), 165-172.

Ghazali, A. K., Ab. Aziz, N. A., Ab. Aziz, K., & Tse Kian, N. (2024). The usage of virtual reality in engineering education. *Cogent Education*, *11*(1), 2319441.

Kumar, V. V., Carberry, D., Beenfeldt, C., Andersson, M. P., Mansouri, S. S., & Gallucci, F. (2021). Virtual reality in chemical and biochemical engineering education and training. *Education for Chemical Engineers*, 36, 143-153.

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2021). A framework for personalised fully immersive virtual reality learning environments with gamified design in education. In *Novelties in Intelligent Digital Systems* (pp. 95-104). IOS Press.

Norton, C., Cameron, I., Crosthwaite, C., Balliu, N., Tade, M., Shallcross, D., Hoadley, A., Barton, G., & Kavanagh, J. (2008). Development and deployment of an immersive learning environment for enhancing process systems engineering concepts. *Education for Chemical Engineers*, *3*(2), e75-e83.

Redel-Macías, M. D., Pinzi, S., Martínez-Jiménez, M. P., Dorado, G., & Dorado, M. P. (2016). Virtual laboratory on biomass for energy generation. *Journal of Cleaner Production*, 112, 3842-3851.

Retnanto, A., Fadlelmula, M., Alyafei, N., & Sheharyar, A. (2019, September). Active student engagement in learning-using virtual reality technology to develop professional skills for petroleum engineering education. In *SPE Annual Technical Conference and Exhibition* (p. D021S037R001). SPE.

Satake, Y., Yamamoto, S., & Obari, H. (2024). Effects of English-speaking lessons in virtual reality on EFL learners' confidence and anxiety. In Peterson, M. & Jabbari, N., Fro*ntiers in Technology-Mediated Language Learning* (pp. 26-40). Oxfordshire: Routledge.

Vlah, D., Čok, V., & Urbas, U. (2021). VR as a 3D modelling tool in engineering design applications. *Applied Sciences*, *11*(16), 7570.

Wu, F., Lu, W., Wang, X., Yang, J., Li, C., Cheng, L., & Xie, Z. (2022). Enhanced virtual reality plant: Development and application in chemical engineering education. *International Journal of Emerging Technologies in Learning* (iJET), *17*(14), 205-220.

Understanding National Income Mechanism: An Experiential Simulation of Aggregate Demand and Supply Dynamics

Ding Hooi Ting*
Universiti Teknologi PETRONAS, Malaysia
*ting.dinghooi@utp.edu.my

Introduction

Understanding national income mechanisms is essential in macroeconomics because it gives students insights into how aggregate demand and supply impact economic outcomes. This knowledge enhances understanding to interpret real-world economic conditions and the impact of government policies. Students can better analyze economic news, understand government policies and implications, and assess how spending, saving, and government decisions affect a country's national income.

Engaging students using experiential simulation gives a hands-on, immersive learning experience. Students can actively participate in scenarios resembling real-world economic activities by simulating the effects of consumer spending, saving, taxation, investment, government spending, exports, and imports. This method develops a more profound, practical understanding of how individual and collective behaviours can influence national income, helping students understand these macroeconomic factors' interconnectedness. The approach can improve comprehension and promote active engagement and long-term retention of key concepts.

There are two objectives for the approach:

1. To improve students' practical understanding of macroeconomic concepts demonstrating the real-world impact of spending, saving, taxation, investment, government spending, and trade on national income.
2. To develop critical thinking and deeper comprehension by transforming abstract economic theories into tangible experiences.

Literature Review

Research on experiential simulations in economics education stresses their efficacy in improving students' understanding of complex macroeconomic concepts. According to Heimberger et al. (2020) and Komlos (2023), simulations provide practical, hands-on experiences that facilitate the gap between theory and real-world application. A study by van Esch et al. (2020), simulations can increase students' engagement and comprehension by allowing them to participate in scenarios that mirror economic activities. Using Keynesian Theory in simulations exhibits how variations in consumer spending and saving behaviours impact national income.

Bowles and Carlin (2020) show that simulations can demonstrate the relationship between aggregate demand, supply dynamics, and national income, improving students' understanding of theoretical concepts. This approach can develop deeper learning and enhance retention and critical thinking (Halliday et al., 2024).

Methodology

To implement the simulation of national income, I have created a simulated scenario to demonstrate the impact of consumer spending and saving behaviours on national income.

Materials Needed

An RM50 note was given to one of the seven participating students. The students were briefed on the simulation's purpose — to understand how different spending and saving behaviours affect national income (Table 1).

Findings

Before the simulation exercise was implemented, all students in the class were asked to fill out a questionnaire. Students were then asked to refill the same questionnaires after the third lecture (for all seven simulations to occur). The findings in Table 2 and Figure 1 show a significant change in understanding of economic concepts after the simulated exercises.

Table 1 Experiential simulation scenarios

Scenario 1: No Savings	Scenario 2: 10% savings
Step 1: Call seven students to the front of the classroom.	Step 1: Repeat the Simulation with the same seven students.
Step 2: Distribute RM50 to one of the students, explaining that they will spend all their money (to another person) without saving any.	Step 2: This time, I have asked each student to save 10% of their RM50 spent and receive (multiplier effect), and subsequently, 20% and 30%.
Step 3: Asked the students to spend their RM50 (multiplier effects) on goods and services within the simulation.	Step 3: Each student will save 10% of the amount received. The students then calculate the total spending and savings.
Step 4: Calculate the total spending and explain how this spending contributes to the national income.	Step 4: In each transaction, each party spends 10% of the amount received on another person, causing the money to decrease progressively as it passes through each individual.
The experiential simulations were repeated for (1) taxation, (2) investment, (3) government spending, (4) exports, and (5) imports.	

Table 2 Results before and after the experiential simulation

Questions	Before	After	Sig
I understand how consumer spending affects national income.	3.46	4.91	0.00
I understand how savings impact national income.	3.36	4.86	0.00
I understand how taxation influences national income.	3.57	4.87	0.00
I understand how government spending affects national income.	3.49	4.76	0.00
I understand the role of investment in determining national income.	3.23	4.87	0.00
I understand how exports affect national income.	3.56	4.85	0.00
I understand how imports affect national income.	3.51	4.87	0.00

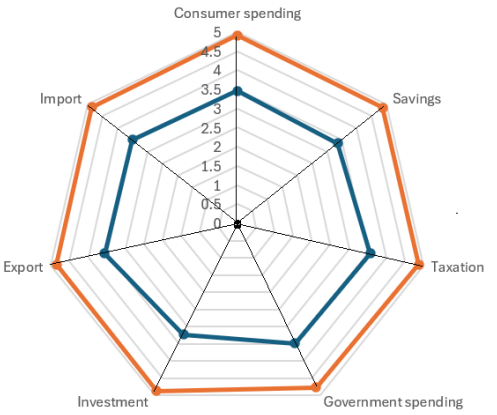


Figure 1 The incremental understanding of the before and after experiential simulation

Discussion

The scenarios above reflect the Keynesian understanding that savings reduce current consumption. The reduction leads to decreased aggregate demand and a lower national income in the short term. This scenario will have spillover effects on other macroeconomic variables.

Through the experiential simulation, students achieve a more profound, practical understanding of macroeconomic concepts affecting national income: consumer spending, saving, taxation, investment, government spending, imports, and exports impact national income. The hands-on simulation experience helps to close the gap between theoretical knowledge and real-world application.

The experiential simulation improved students' engagement and knowledge retention of complex macroeconomic concepts. Students' active participation in the simulations created a more engaging learning environment, leading to a better understanding and relation to real-world economic scenarios.

Students also advance their practical skills by examining the different economic scenarios and understanding the impact of various economic behaviours on national income. The experiential simulation provides an enhanced understanding and application of macroeconomic variables.

Conclusion

Experiential simulation has significantly improved students' understanding of macroeconomic variables and national income. It has also enhanced their knowledge and understanding of complex economic events and improved their analytical capabilities regarding national and international economic variables.

Acknowledgement

This research was conducted in class, and no funding was received.

References

Bowles, S., & Carlin, W. (2020). What students learn in economics 101: Time for a change. *Journal of Economic Literature*, *58*(1), 176-214.

Halliday, S. D., Makler, C., McKee, D., & Papadopoulou, A. (2024). Improving student comprehension through interactive model visualization. *International Review of Economics Education*, *47*, 100296.

Heimberger, P., Huber, J., & Kapeller, J. (2020). The power of economic models: the case of the EU's fiscal regulation framework. *Socio-Economic Review*, *18*(2), 337-366.

Komlos, J. (2023). *Foundations of real-world economics: What every economics student needs to know*. Oxfordshire: Routledge.

van Esch, P., von der Heidt, T., Frethey-Bentham, C., & Northey, G. (2020). The effect of marketing simulations on student engagement and academic outcomes. *Marketing Education Review*, *30*(1), 43-56.

Visualising 2D Models and Understanding Functions through Desmos

Farahani Yusoff*, Wan Sharizan Wan Mamat Pauzam
Universiti Teknologi PETRONAS, Malaysia
*farahani.yusoff@utp.edu.my

Introduction

Students understand more about mathematical functions through Desmos. By allowing real-time manipulation of graphs, Desmos assists in visualising function properties, transformations, and relationships. The study also explores how Desmos complements Inquiry-Based Learning (IBL), an educational approach that promotes exploration and problem-solving. A practical assignment involving 680 students highlights the tool's potential to deepen mathematical comprehension and foster an engaging, technology-driven learning environment.

Literature Review

Based on Dy (2024) Desmos, an online graphing tool, effectively enhances students' understanding of mathematical functions through visual interaction and real-time manipulation of graphs. Desmos is particularly valuable in helping students grasp function properties, transformations, and relationships (Johnson, 2021). Previous studies indicate that Desmos facilitates a more interactive and engaging learning experience, improving comprehension of complex mathematical ideas (Dani & Ashok, 2025). The tool's interactive nature complements Inquiry-based Learning (IBL), an educational approach emphasising exploration, questioning, and problem-solving. IBL encourages students to engage deeply with concepts, collaborate with peers, and develop creative solutions, making learning more relevant and engaging (Brown & Taylor, 2022). This approach aligns with the findings of Brown and Taylor (2022), who argue that integrating technology with IBL can significantly improve student outcomes by making abstract concepts more accessible and engaging.

The literature emphasises the value of integrating Desmos into mathematics education, particularly when combined with Inquiry-Based Learning approaches (Dy, 2024; Johnson, 2021). Combining these tools and methods offers a powerful strategy for enhancing students' understanding of mathematical functions, fostering engagement, and promoting a more interactive and exploratory learning environment (Dani & Ashok, 2025).

Research Methodology

Research Design

This study employs a mixed-methods approach to investigate the effectiveness of Desmos, an online graphing tool, in enhancing students' understanding of mathematical functions. The research combines quantitative data analysis with qualitative insights to comprehensively evaluate the tool's impact on student learning outcomes.

Participants

The study involved 680 foundation students enrolled in a mathematics course at a university. These students were organised into 68 groups, each comprising approximately 10 members. Participants were selected based on their course enrollment and willingness to participate in the study.

Materials

The primary tool used in this study was Desmos, an online graphing calculator that allows users to visualise and manipulate mathematical functions in real-time. The instructor provided the students with instructional materials on how to use Desmos, including tutorials and example problems.

Procedure

The study was conducted over 10 weeks during a semester. The students were given a project-based assignment that required them to design a two-dimensional model using Desmos. The model was intended to represent a valuable scenario during a flood. Students were required to incorporate a variety of mathematical functions with different domains and ranges and to use inequalities to represent complex areas and boundaries.

Week 1-2: Introduction to Desmos and the project assignment. Students received training on how to use Desmos effectively.

Week 3-7: Students worked in their assigned groups to design their models using Desmos. During this period, instructors provided guidance and support as needed.

Week 8-9: Students finalised their models and prepared presentations.

Week 10: Students presented their models to the class, explaining the mathematical concepts and functions used in their designs.

Result and Discussions

Students can visualise two-dimensional models using Desmos based on the topic given flood. Both groups designed practical water transportation to rescue victims when flash floods occur. Figure 1 is a ship called De' Salveum, whereas Figure 2 is a boat called D' Saviour. The functions to design the boat and the ship are linear, quadratic, polynomial, circular, and trigonometric. Furthermore, students strengthen their knowledge and understanding of the intervals and inequality concept as it allows students to visualise the interval and inequality by coloured lines and regions of the ship and boat designed. To create the complete ship and boat design, each shape is represented by various functions with desired intervals and inequalities. Next, Figure 3 shows the students' feedback on the course outcome survey related to the assignment.

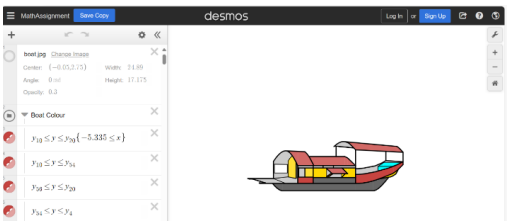


Figure 1 De'Salveum

Based on the student's boat design by using a Desmos graphing calculator, it shows that the student used 60% of trigonometric functions such as the sine function, the cosine function, the tangent function, the secant function, the cosecant function and the cotangent function with different amplitudes. On the other hand, another 40% of the functions used consist of polynomials, rational functions, circles,

hyperbolic functions, and ellipses. Various parts of the boat require distinct shapes that a single function can't capture. For example, the hull might need a parabolic shape. At the same time, the poll used stands for the ship represented by a vertical line, and the roof needs curved shapes requiring some trigonometric, quadratic, and hyperbolic functions to ensure smooth curve visualisation. The colored region visualises the inequality used. For example, all the roof shading was restricted to two functions, such as quadratic and linear functions. The quadratic inequality must be less than zero, and the linear inequality must be greater than zero. In conclusion, each shape corresponds to different linear, quadratic, or piecewise functions to complete the ship design.

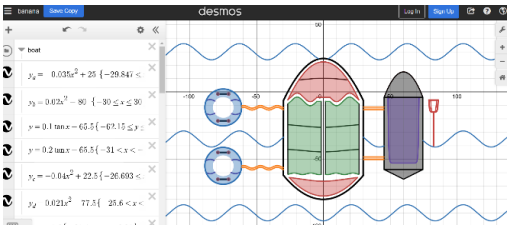
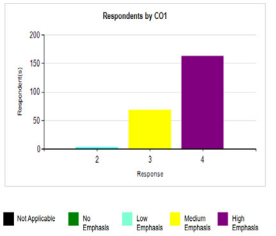


Figure 2 D' Saviour

Based on the student's boat design by using the Desmos graphing calculator, it shows that the student used 50% of trigonometric functions, such as the sine function, the cosine function, and the tangent function with different amplitudes, and another 50% of the functions used consist of polynomial, rational functions and circles. The trigonometric functions mainly cover the wave, rope, and curve shapes around the boat. The circle covers the swimming float, and other parts of the boat use polynomial and rational functions. The purpose of using different functions is to have a smooth boat design. The student used multiple functions to ensure that each part of the boat was precisely placed in the correct position. For example, students restrict the domain and range of a quadratic function to represent the paddle's tip while using a linear function for the paddle's shaft. The coloured region is based on the inequality chosen. For example, the colored area on the boat formed between two functions, such as quadratic and trigonometric functions. The trigonometry inequality must be greater than zero, and another inequality must be less than zero.



Result CO1	
Total Student Response	235
Total Mark	865
Average	3.680851063829787234042553191 5
Conclusion	Attainment is placed between Medium and High Emphasis.

Figure 3 Feedback Survey

The survey results indicate that students are satisfied with Course Learning Outcome 1 (CLO1), finding that the associated assignment effectively supported their achievement of this outcome. The assignment's precise alignment with CLO1 allowed students to practically apply concepts of functions, graphs, and inequality, enhancing their understanding and confidence. This positive feedback confirms that the assignment is well-designed to meet and plays a key role in student satisfaction with the course.

Conclusion

This study showed that students can understand mathematical functions through visual interaction and real-time graph manipulation. Based on the previous studies, Desmos promotes a more interactive and engaging learning experience that leads to better comprehension of complex concepts. When integrated with IBL, Desmos strengthens key mathematical concepts and encourages critical thinking, collaboration, and creativity. The alliance between Desmos and IBL creates a

dynamic, exploratory learning environment in mathematics education, ultimately improving student outcomes and deepening their grasp of mathematical functions.

References

Brown, T., & Taylor, R. (2022). Integrating technology with inquiry-based learning: Enhancing student outcomes in mathematics education. *Journal of Educational Technology, 18*(2), 123-136.

Johnson, P. (2021). The impact of Desmos on students' understanding of mathematical functions. *Mathematics Education Review*, *35*(4), 45-60.

Dani, A., & Ashok, D. Exploring the Impact of DESMOS on Students' Understanding and Learning of Transformations, *Conference: Proceedings of the HCT International General Education Conference (HCTIGEC 2024),* (71-87), Dordrecht: Atlantis Press.

Dy, A.C. (2024). Implementation of DESMOS as a Teaching Tool in Graphing Functions in the New Normal, *Journal of Research and Investigation in Education*, 2(2), 59-64. Doi:10.37034/residu.v2i2.175

The Readiness of The Psychology Lecturer to Implement VR Case Study: VR to Stimulate Real–World Experiences and Improve Knowledge Retention

Siti Aminah Harun[*1], Wan Nabilah Syafiqah Wan Abd Rahim[2], Nur Shyuhadah Rasli[3]
[1] Universiti Malaya Wales, Malaysia
[2] UNITAR International University, Malaysia
[2,3] Universiti Sains Malaysia, Malaysia
[*]siti.aminah@umwales.edu.my

Introduction

Readiness accepts this digital technology compared to studies of more modern models and the factors behind it. Studies have indicated that digital transformation can impact any sector or organisation (Naji et al., 2024; Maki et al., 2022; Matt et al., 2015). Although digital transformation was incorporated into construction practices early on, it also simplifies the process to better meet modern users' or generations' needs and preferences.

Literature

The use of technologies and their most relevant applications in industrial services towards education and awareness makes it possible to measure these technologies' adoption levels (Ribeiro et al., 2024). Reality technology is introduced to enhance the quality of professional services, such as lecturers and consultants, in their study courses. The study aims to form a complex for improving the professional attributes of trainers based on virtual and additional reality technology (Kuspanov et al., 2024).

The rapid advancement of digital technology has enabled digital transformation across sectors. However, this proposed framework model is changing as key players in the education sectors progressively identify and embrace the vast opportunities and associated benefits of using digital tools and technologies to improve the performance and outcomes of the overall success of learning outcomes based on Outcome Based Education (OBE) in psychology undergraduate level.

Analysis: Exploring model fit R2 & Path Coefficient towards Readiness to Virtual Reality (VR)

The value of R^2 provides information about the dependent variables (endogenous) and the extent of variation created by the independent variables (exogenous). Higher R^2 values suggest that the structural model can predict. In SmartPLS, the exogenous to endogenous variables were tested for the structural model using the path coefficient indicator value and t-values.

Result Discussion

Results showed that Attention could explain 60.8% of the variance in five main factors. It manages to explain the readiness implementation towards VR. For the five predictors on VRRD, the coefficient of determination, $R^{2,}$ was 0.608. PBC ($\beta = 0.261$, $p < 0.001$), EXPERT ($\beta = 0.450$, $p < 0.01$), and ATT ($\beta = 0.004$, $p < 0.001$) were found to have a positive relationship towards VRRD, thus

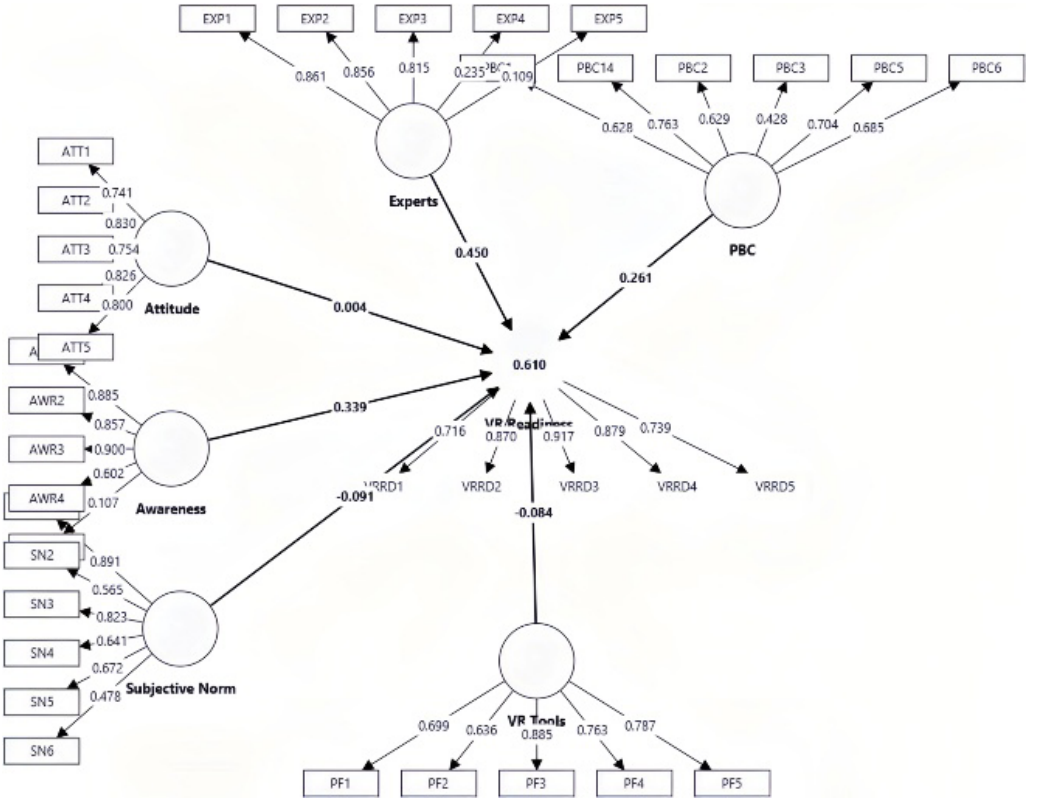


Figure 1 Structural model testing results

supporting H1. Meanwhile, AWARENESS (β = 0.339) and Subjective Norm (β = -0.091) were found to be insignificant towards VRRD, thus not supporting H2.

Hypothesis 1: Internal has a positive influence on the readiness of VR implementation
Internal capabilities like attitude, PBC, and expertise usually influence internal factors. Likewise, the researcher intends to explore the locus of perceived behaviour control in extended TPB by injecting the expert's variable.

Hypothesis 2: External has a positive influence on the readiness of VR implementation
External factors continuously divert the Awareness and Subjective Norm in VR implementation because of limited internet access, sources, and community sharing.

Conclusion

The suggested framework would enable scholars and experts in the construction course to create an assessment tool akin to the structural equation model (SEM) or the analytical hierarchy process (AHP), which would gauge and assign a score to a university level for psychology undergraduate of preparedness for digital transformation. The pre-construction, construction, and facility management stages might all employ this paradigm. This framework was developed because of this research to help facility management companies, clients, organisations, contractors, and designers understand how digital transformation is implemented in their respective domains and to support decision-makers in setting up action to adapt related technologies in their respective phases.

Acknowledgement

Authors wishing to acknowledge assistance or encouragement financial & institutional support under academic allocation funding Universiti Malaya Wales (PSYG240811UMW-SAB) Internal Research Grant (RMC/2024/11).

References

Kuspanov, N., Botagariyev, T., Ryskaliyev, S., Doshybekov, A., Syzdykov, A. & Gabitov, A. (2024). The influence of information technology on the professional readiness of future trainers in Kazaksha kures. *Retos, 51*, 365-372.

Maki, O. Alshaikhli, M. Gunduz, M. Naji, K.K., Abdulwahed, M. Development of digitalisation road map for Healthcare Facility Management. IEEE Access 2022, 10, 14450– 14462.

Matt, C.; Hess, T.; Benlian (2015). A. Digital Transformation Strategies. *Bus. Inform. Syst. Eng., 57*, 339–343.

McClure, C., & Seock, Y. K. (2020). The role of involvement: Investigating the effect of brand's social media pages on consumer purchase intention. *Journal of Retailing and Consumer Services*, *53*, 101975.

Naji, K. K., Gunduz, M., Alhenzab, F., Al-Hababi, H., & Al-Qahtani, A. (2024). Assessing the Digital Transformation Readiness of the Construction Industry Utilising the Delphi Method. *Buildings*, *14*(3), 601.

Parnell, J. A., & Crandall, W. (2021). What drives crisis readiness? An assessment of managers in the United States: The effects of market turbulence, perceived likelihood of a crisis, small to medium sized enterprises and innovative capacity. *Journal of Contingencies and Crisis Management*, *29*(4), 416–428.

Parnell, J. A., Koseoglu, M. A., & Spillan, J. E. (2010). Crisis readiness in Turkey and the United States. *Journal of Contingencies and Crisis Management*, *18*(2), 108–116.

Ribeiro, D. B., Coutinho, A. D. R., Satyro, W. C., Campos, F. C. D., Lima, C. R. C., Contador, J. C., & Gonçalves, R. F. (2024). The DAWN readiness model to assess the level of use of Industry 4.0 technologies in the construction industry in Brazil. *Construction Innovation*, *24*(2), 515-536.

Enhancing Student Development through Problem-Based Learning in Physics: Integrating Scientific Research and Soft Skills for Real-World Applications

Easter Joseph*, Nurul Izzah M Ridwan
Universiti Teknologi PETRONAS, Malaysia
*easter.joseph@utp.edu.my

Introduction

Problem-based learning (PBL) has rapidly grown in university settings, particularly in Physics courses, as a teaching method that prepares students for real-world problem-solving (Bonafide et al., 2021). This approach involves presenting students with a problem or challenge and having them work collaboratively to propose scientific and engineering solutions. One key aspect of problem-based learning is the requirement for students to present their findings as a poster presentation (Jamaludin et al., 2012). This allows students to develop crucial communication and teamwork skills, enhancing their understanding of the course content (Petersdorf, 1993). Research has shown that incorporating scientific project research into problem-based learning programs can benefit student learning. Conducting basic scientific research and reflecting on their work helps students develop better time management, role-sharing, and work-tracking skills.

Furthermore, the feedback provided by lecturers on their research work can guide students in improving the logic and quantitative representation of their findings (Nakamura, 2015). Beyond the development of process skills, problem-based learning has been found to foster a deeper understanding of course contents. The implementation of problem-based learning in Physics courses is particularly significant, as there is a growing global concern about the need to make physics education more effective and attractive to students (Jolly, 2009).

In this study, PBL was implemented within a physics course. Students engaged in a fundamental scientific research framework and presented their findings through a poster presentation. This process required students to generate ideas based on predictions, experiences, and problem-solving skills. Thus, the primary objective of this research is to examine students' learning experiences throughout this PBL project.

Methodology

This study involved 80 foundation students at Universiti Teknologi PETRONAS (UTP) who participated in a 10-week Physics project as part of their project assignment. At the beginning of the semester (Week 1), the students were briefed on the project prompt and divided into 20 groups of 4 members each. They prepared a poster presentation with key elements such as background information, problem identification, objectives, scientific solutions, and a conclusion. For the project, students were required to develop a project title that addressed an issue in a suburban area and proposed a unique, practical, and feasible solution to improve the quality of life for the community. They also had to address one of the specified

Sustainable Development Goals (SDGs): SDG 3 (Good health and well-being), SDG 9 (Industry, innovation, and infrastructure), or SDG 13 (Climate action). From Week 2 until 5, students worked in groups to analyse the problem, brainstorm, and develop their scientific and engineering solutions through modification, innovation, or invention based on any Physics topics, including kinematics, dynamics, electricity, magnetism, or optics. During this period, the students gathered information through research and discussion to address the problem and formulate a solution. Each team member has tasks and must ensure the poster's content is coherent. In Week 6, all groups had to submit their project draft and consult with the lecturers on their proposal. After the consultation week, the groups polished the poster presentation by considering the lecturer's feedback and the project's criteria. At the end of week 10, all teams presented their projects through the prepared poster. Subsequently, students' reflection was analysed through an online survey. The questionnaire consists of 10 questions designed to evaluate students' grasp of physics concepts, scientific skills, and soft skills.

Results and Discussion

This study examined three primary areas of student development: understanding physics concepts, scientific skills, and soft skills. In understanding physics concepts, most students reported that the project helped them better comprehend physics, as shown in Figure 1. The students could analyse the concepts more effectively and apply them in practical, real-world scenarios. Moreover, they could experiment with the ideas until they arrived at the most relevant solutions and reasoning. This process allowed students to actively construct their understanding while also developing the ability to improvise on existing physics applications.

For the questions related to scientific skills, as displayed in Figure 2, students indicated that preparing the poster helped cultivate their scientific inquiry skills. Inquiry-based learning refers to scientists' different methods to explore and understand the natural world. This approach is a starting point for independent initiatives that help strengthen students' practical involvement in research processes, sciences, and knowledge management. This project enabled them to develop essential research skills such as hypothesis formulation, experimental design, data analysis, and interpretation, which fostered students' curiosity and exploration. To produce reasonable scientific solutions, students must view the problem from multiple perspectives and explain it from various angles. Although the foundation students were only expected to identify scientific issues, generate ideas for solutions, and present the ideas effectively, these experiences would ignite their scientific inquiries and serve as a stepping stone for engaging in more complex research activities

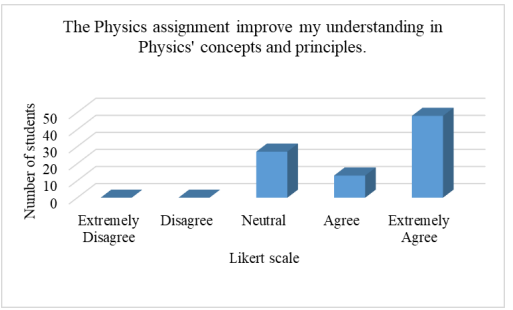


Figure 1 Bar chart of understanding physics concepts.

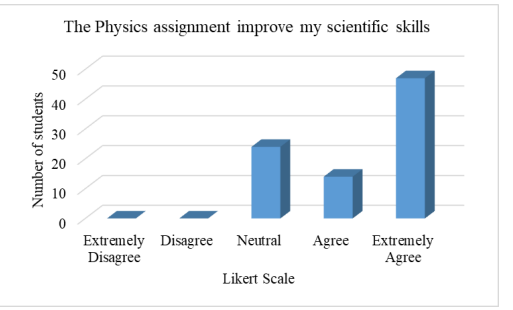


Figure 2 Bar chart of scientific skills

later in their undergraduate and postgraduate studies. Furthermore, these activities will assist the students in developing better skills as engineers and scientists in the future.

The project positively impacts students' soft skills, as displayed in Figure 3, especially those crucial in the engineering and science fields. Among the essential skills sought after in today's graduates are problem-solving, critical thinking, and communication. This project allowed students to hone these skills through activities such as group collaboration, presentation of research findings, and critical discussion of different approaches to solving problems. These experiences prepared students for their future careers and contributed to their overall personal and professional development. Moreover, employers are increasingly looking for graduates with strong transferable skills that can be applied across various contexts. Therefore, embedding engineering skills in the curriculum is crucial for higher education, mainly as graduate attributes have increasingly been considered more important than the actual degree.

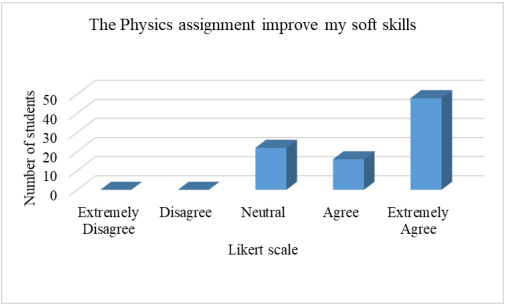


Figure 3 Bar chart of soft skills

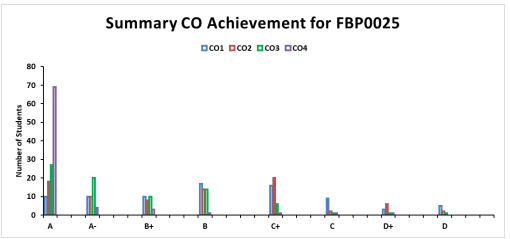


Figure 4 Bar chart of CO achievement for the FBP0025 students

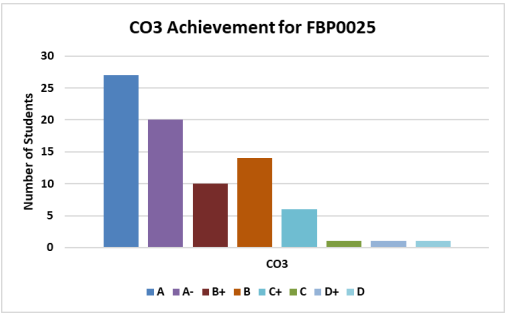


Figure 5 Bar chart of CO3 achievement for the FBP0025 students

Figure 4 shows the course outcome (CO) achievement for Physics II (FBP0025), grouped by grades. This course has four Cos; CO1 involves explaining the basic principles and concepts of electricity, electromagnetism, optics, and modern physics; CO2 focuses on applying the basic principles and ideas of the topics; CO3 involves analysing problems related to these principles; and CO4 involves demonstrating laws and concepts through laboratory experiments. This project assignment is an assessment that falls under CO3. To evaluate students' performance in this area, CO3 is extracted from the bar graph, as shown in Figure 5. It can be observed that nearly 90% of students achieved a grade of B or higher. This indicates that students can apply the concepts of physics and analyse problems to arrive at scientific solutions. Furthermore, by completing this project assignment, students can understand how basic physics concepts significantly impact their solutions.

Conclusion

This paper highlights the experience of foundation students in preparing the poster presentation by conducting basic scientific research. Most students appreciate and feel that

this project has improved their understanding of physics concepts by experimenting with the concepts to produce relevant solutions and reasoning. In addition, the scientific skills they acquired stimulated their curiosity to learn more and prepared them for more complex research activities. Finally, the soft skills they develop are critical in preparing them for their future careers.

Acknowledgement

This research work is supported by the Centre for Foundation Studies, Universiti Teknologi PETRONAS.

References

Bonafide D. Y., Saregar Y. A., and Fasa M. I. (2021). Problem-based learning model on students' critical-thinking skills: A meta-analysis study. *Journal of Physics: Conference Series, 1796*(1).

Jamaludin M. K., Mohd Yusof K., Harun N. F., and Hassan S. A. H. S. (2012). Crafting Engineering Problems for Problem-Based Learning Curriculum. *Procedia - Social and Behavioral Sciences, 56*, 377-387.

Jolly P. (2009). Research and Innovation in Physics Education: Transforming Classrooms, Teaching, and Student Learning at the Tertiary Level. *AIP Conference Proceedings, 1119*(1), 52-58.

Nakamura S. (2015). Effects of report-writing on a multi-stage-experience educational program using an autonomous mobile robot. *IEEE Frontiers in Education Conference (FIE)*, 1-4.

Petersdorf, R. G. (1993). The Transition. *Academic Medicine, 68*(1), 44.

Enhancing Student Engagement and Learning Through Class Kick Strategies

Numair Ahmed Siddiqui*[1], Mohamed Elsaadany, Syed Harron[2], Manoj Mathew[3], Mona Arif Muda[4]
[1,2]Universiti Teknologi PETRONAS, Malaysia
[2]University of Sargodha, Pakistan
[3]Kingston University, London, United Kingdom
[4]Universitas Lampung, Indonesia
**numair.siddiqui@utp.edu.my*

Introduction

In contemporary education, student engagement is a critical factor influencing learning outcomes. Traditional teaching methods often fail to captivate students' interest, leading to disengagement and suboptimal academic performance. Class kick strategies encompass a variety of approaches designed to make learning more interactive and enjoyable. These strategies include active learning techniques, technology integration, creative projects, and experiential learning. Research has shown active learning can improve critical thinking skills and knowledge retention (Hew et al., 2014; Prince, 2004). Technology integration, such as gamification and virtual reality, has enhanced student motivation and engagement (Deterding et al., 2011). Creative projects and experiential learning provide hands-on experiences that help students apply theoretical knowledge to real-world contexts (Kolb, 1984). This study builds on these findings by implementing these strategies for undergraduate and postgraduate online teaching and assessing their impact. This paper introduces the concept of "class kick" strategies, designed to invigorate classroom dynamics and foster a more interactive and enjoyable learning experience. By examining the implementation and results of these strategies, we aim to provide a comprehensive understanding of their effectiveness in enhancing teaching and learning.

Problem Statement

Despite recognising the importance of student engagement, many online classes continue to rely on passive teaching methods that do not fully engage students. This lack of engagement can decrease motivation, lower academic achievement, and a negative attitude toward learning. There is a need for innovative approaches that can transform the classroom environment and actively involve students in the learning process (Hamari et al., 2014). This study investigates the impact of class kick strategies on student engagement and learning outcomes for online and distance learning courses.

Objectives

1. To investigate the effect of class kick strategies on student motivation and enthusiasm towards learning, comparing pre- and post-intervention data.
2. To evaluate the changes in students' academic performance, including test scores and project evaluations, as a result of implementing class kick strategies.
3. To collect qualitative data through focus group interviews and classroom observations to understand the experiences and perceptions of students and teachers regarding the class kick strategies.

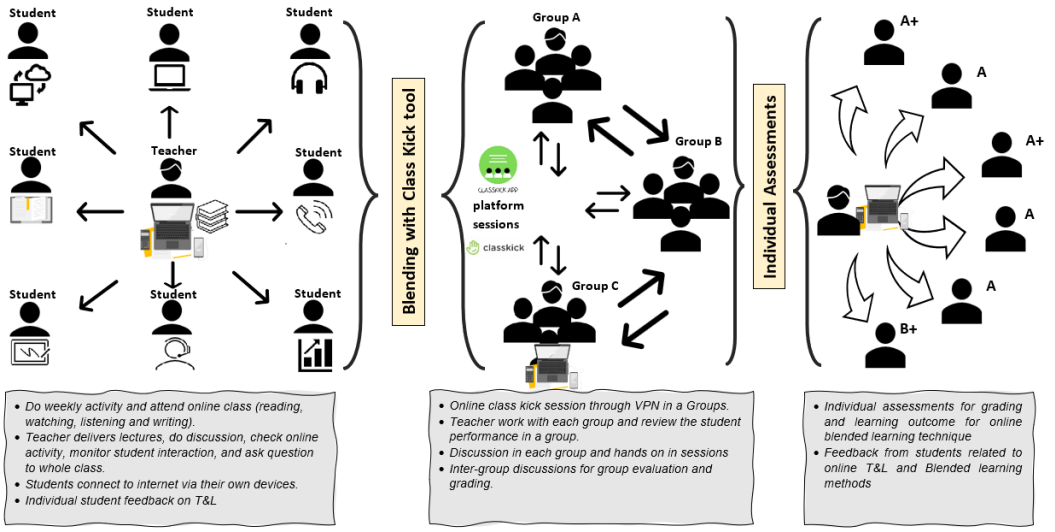


Figure 1 The approach of blended learning in online teaching and learning with Class Kick sessions and assessments with individual students and in group.

Method and Workflow

The study was conducted through online teaching and distance learning courses with a sample of 20 students across various subjects. A mixed-methods approach was used, combining quantitative and qualitative data collection techniques. The following class kick strategies were implemented over a semester: In this context, blended learning can be composed of two main sections: online teaching that can be completed by students and hands-on sessions, which are continuations of online activities that allow students to apply online teaching understanding into real-time practical analysis. Online teaching focuses on individual performance, while the class kick-off session activities emphasise cooperative group activities during online sessions and assessments for each student. The students can also submit their assessment with feedback at the end of the course week. Further, this learning environment is shown in Figure 1.

Participant and Implementation

The participants in the learning study consisted of students enrolled in a particular course (online or distance learning). Students were selected by using purposeful sampling. The criteria used to select student participants included the following: (1) enrolment in the course, (2) ability to use basic computer and internet tools, and 3) regular course attendance. Participants consisted of at least a total of 20 students from five groups. The following course planning with assessment is shown in Figure 2.

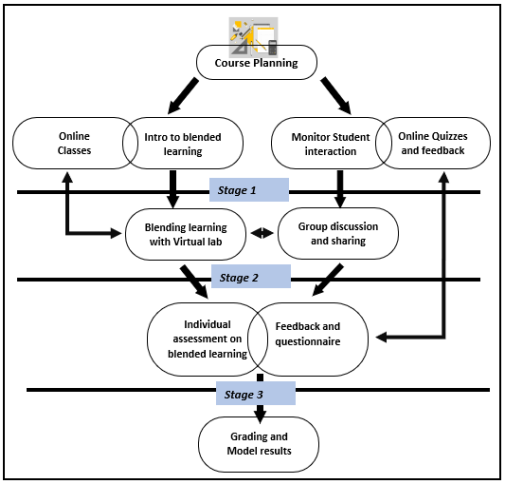


Figure 2 Course planning and assessment

Pilot Results

Results obtained from this blended technique are shown here for the quantitative effectiveness of this online approach. Students were evaluated based on their performance in online classes to check how practical this approach is. Students were made to cover most of their studies through the existing conventional method followed by online learning up to week 5. The students were given assignments and other related tasks simultaneously to check their performance and understanding. The result (Figure 3) shows that with the blended approach, students' performance improved 20% more than when they studied only through the traditional teaching techniques. The understanding of the students was observed to have improved more by using a blended approach with online tools. Although online teaching is very challenging, using this blended learning strategy will give students a new vision and insight. It helps the instructor/lecturers to run the courses successfully.

Conclusion

In conclusion, this study highlights the effectiveness of "class kick" strategies in enhancing student engagement and learning outcomes, particularly in online and distance learning environments. By integrating active learning techniques, technology, creative projects, and experiential learning, educators can create a more dynamic and interactive classroom experience. The pilot results show that students exposed to blended learning methods, combining traditional and online techniques, performed 20% better than those taught solely through conventional methods. These findings suggest that class kick strategies can significantly improve student motivation, enthusiasm, and academic performance, offering a promising approach to addressing the challenges of student disengagement in online education.

Grades	Conventional way	Online and conventional
0.00 - 5.00	0	0
5.00 - 10.00	0	0
10.00 - 15.00	0	0
15.00 - 20.00	0	0
20.00 - 25.00	0	0
25.00 - 30.00	0	0
30.00 - 35.00	4	2
35.00 - 40.00	6	3
40.00 - 45.00	4	2
45.00 - 50.00	4	6
50.00 - 55.00	2	5
55.00 - 60.00	0	2
Total Students	**20**	**20**

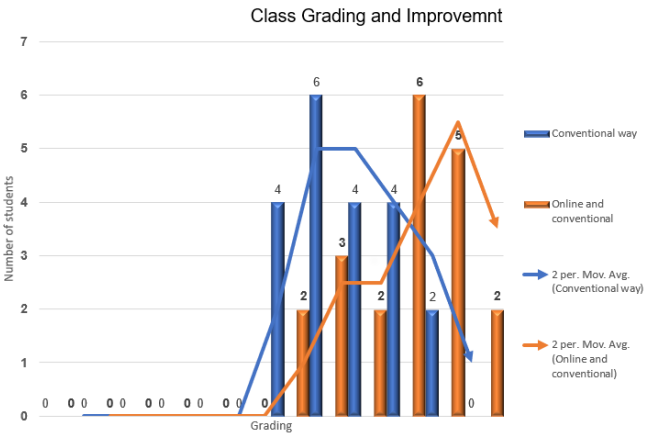


Figure 3 Student results in teaching and learning from week 1 to week 5 with assessments and its improvement with blended learning with an online teaching approach

Acknowledgement

The authors would like to thank Universiti Teknologi PETRONAS for allowing me to present this work. Thank you for acknowledging it is extended to Universitas Lampung for external funding for this work with cost centre 015ME0-367.

References

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gracefulness: defining "gamification". In *Proceedings of the 15th International Academic Mind Trek Conference: Envisioning Future Media Environments* (pp. 9-15). ACM.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? a literature review of empirical studies on gamification. In *47th Hawaii International Conference on System Sciences* (pp. 3025-3034). IEEE.

Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review, 12*, 45-58.

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Nerw Jersey: Prentice Hall.

Prince, M. (2004). Does Active Learning Work? A Review of the Research. *Journal of Engineering Education*, *93*(3), 223-231.

Collaborative Learning Through Role-Playing: Enhancing System Design Skills in Students

Zuraini Hanim Zaini*, Shakirah Mohd Taib
Universiti Teknologi PETRONAS, Malaysia
*zuraini.zaini@utp.edu.my

Introduction

In the rapidly evolving technological landscape, proficiency in system design is a crucial asset for students poised to enter the workforce (Gupta et al., 2020). However, many students in foundational programs lack practical experience in system development, presenting a significant challenge to their learning (Decker & Simkins, 2016). Without hands-on experience, students often struggle to comprehend how systems work as integrated units that meet user needs and achieve specific business goals (Cook et al., 2017).

In addressing the gap, this study explores using role-playing exercises as a pedagogical strategy to enhance students' understanding of system design. Role-playing activities allow students to simulate real-world scenarios where multiple user types interact with the system. This enables them to visualise and appreciate the interconnectedness of system components (Shilton et al., 2020). This experiential learning approach fosters a more profound comprehension of system functionalities and encourages critical thinking and peer collaboration (Doğantan, 2020).

Literature Review

Role-playing exercises have long been recognised as a valuable tool in system design, offering a unique approach to understanding complex systems and the interactions between their various components. By immersing participants in simulated scenarios, role-playing exercises can provide a rich and embodied understanding of the contextual factors that shape system behaviour, allowing designers to uncover insights that may not be readily apparent through more traditional analytical methods (Cook et al., 2017; Doğantan, 2020).

Moreover, role-playing exercises can be a powerful tool for exploring the potential impacts of system-level interventions, allowing designers to experiment with different scenarios and observe the emergent outcomes (Avin et al., 2020; Zhao et al., 2022). This can be especially valuable when dealing with complex, open-ended problems where possible consequences may not be immediately apparent. Through the careful design and facilitation of role-playing exercises, system designers can tap into the rich experiential knowledge of participants, fostering collaborative learning and the generation of novel insights that can inform the design process (Decker & Simkins, 2016; Gupta et al., 2020).

Research Methodology

This study utilised a mixed-methods approach to evaluate the impact of role-playing exercises on system design understanding and skill development. The quantitative and qualitative data were collected to comprehensively

assess learning outcomes across knowledge acquisition, skill development, engagement, learning application, collaboration, feedback, and overall satisfaction.

The study involved 114 students from a foundational technology and business program, specifically in a Visual Programming course. Participants were divided into 24 groups of 4-5 students, each with assigned roles: Project Manager, System Analyst, User Representative, and Developer. These roles aligned with standard system design functions to simulate real-world collaborative environments.

A structured survey comprising 25 items was administered post-exercise to evaluate various dimensions of the role-playing experience (Table 1). Participants responded using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), complemented by open-ended items for qualitative feedback. Quantitative data were analysed through descriptive statistics — calculating mean scores, standard deviations, and frequencies for each survey domain — and inferential tests to identify significant patterns. This methodology aligns with established practices in educational research, where mixed-method approaches effectively capture both quantitative metrics and qualitative insights (Zainuddin et al., 2024)

Quantitative data were analysed using descriptive statistics and inferential tests. Mean scores, standard deviations, and frequencies were calculated for each survey domain. Qualitative responses underwent thematic analysis to identify recurring themes and insights related to role-playing benefits and challenges in system design learning.

Table 1 Survey design and data collection framework for assessing role-playing effectiveness in a visual programming course

Survey Domain	Number of Items	Focus	Example Question
Knowledge Acquisition and Skill Development	10	Understanding system functionalities, identifying requirements, and building confidence in technical application	"I feel more confident in identifying system requirements."
Engagement and Motivation	5	Assessing engagement levels and enjoyment from the interactive role-playing exercise	"The role-playing activity made learning more enjoyable."
Application of Learning	4	Evaluating readiness to apply knowledge and skills in future visual programming projects	"I feel prepared to apply this knowledge in real-world settings."
Collaboration and Teamwork	3	Measuring teamwork skills and valuing diverse perspectives within the group	"The activity improved my ability to work in a team."
Feedback and Reflection	2	Assessing the helpfulness of feedback and reflective discussions in enhancing learning	"Feedback from peers and instructors helped improve my work."
Overall Satisfaction	1	Gauging overall satisfaction with the role-playing exercise and interest in similar future activities	"I am satisfied with the role-playing exercise."

Result and Discussions

The study's results highlight the effectiveness of role-playing exercises in enhancing students' understanding and skills in a Visual Programming course. As shown in Figure 1, 82% of students reported improved knowledge and skill development, with 85% finding the exercise engaging. Additionally, 80% felt prepared to apply what they had learned in future projects, demonstrating effective knowledge transfer. Collaboration skills improved, with 90% valuing diverse perspectives and 75% finding feedback helpful for their learning. Overall, 88% expressed satisfaction, recommending similar activities for future courses. These findings indicate that role-playing fosters critical thinking collaboration and prepares students for real-world challenges in technology and business.

The findings of this study align with existing literature that supports role-playing as an effective pedagogical strategy in technology education. Previous research has shown that experiential learning approaches, such as role-playing enhance student engagement and knowledge retention (Acharya et al., 2019; Doğantan, 2020). By immersing students in realistic scenarios, they can better connect theoretical concepts to practical applications, leading to a more profound understanding of system design principles. The significant improvement in students' confidence in identifying system requirements further indicates that role-playing can effectively bridge the gap between theory and practice, a critical technological aspect.

Additionally, students' high levels of engagement reinforce the notion that active learning environments foster intrinsic motivation. According to Liao et al. (2022), motivated learners are more likely to take ownership of their learning process, resulting in improved academic outcomes. The interactive nature of role-playing exercises maintains student interest and encourages collaboration among peers, allowing them to develop essential teamwork skills that are vital in the technology industry.

Moreover, the positive feedback and reflective discussions highlighted in the results highlight the importance of formative assessment in learning. As Jiang et al. (2021) noted, constructive feedback is crucial for promoting deeper insights and continuous improvement. By incorporating reflective practices, students can critically evaluate their performance, enhancing self-awareness and skill growth.

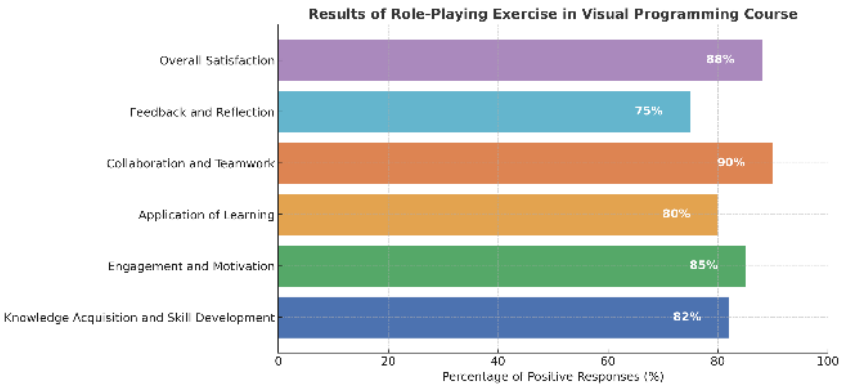


Figure 1 Survey results on the effectiveness of role-playing exercises in enhancing students' understanding and skills in the visual programming course

Overall, the success of the role-playing exercises in this study underscores the need for educators to adopt innovative teaching methodologies that prepare students for real-world challenges. As the technology and business landscape evolves, equipping students with practical, collaborative, and critical thinking skills is paramount. This study not only adds to the growing body of evidence supporting the effectiveness of role-playing in education but also provides a framework for integrating such methodologies into curricula to foster the next generation of technology professionals.

Conclusion

In conclusion, the role-playing exercises implemented in this study have proven effective in enhancing students' understanding of system design. This approach prepares students for the complexities of real-world technology and business environments by fostering knowledge acquisition, skill development, engagement, and collaboration. The incorporation of role-playing as a pedagogical strategy is supported by recent research, highlighting its effectiveness in enhancing student engagement, knowledge retention, and practical learning application. Future research could explore the long-term impacts of role-playing on students' career readiness and professional development, as well as the potential for integrating technology in role-playing scenarios to enhance learning outcomes further.

References

Acharya, S., Sahu, S., & Sahu, R. (2019). Role-playing as an effective teaching strategy for enhancing knowledge retention in nursing education. *Nurse Education Today, 76*, 10-15.

Avin, S., Kauffman, L., & Shapiro, J. (2020). Role-playing as a method for exploring complex systems: A case study in system design. *Systems Research and Behavioral Science, 37*(5), 685-698.

Cook, M., Taylor, A., & Carter, C. (2017). *Engaging systems through role-playing: A methodological approach for design exploration*. *Journal of System Design*, 12(3), 45-60.

Decker, S., & Simkins, S. (2016). The importance of experiential learning in business education: A role-playing approach. *Business Education Innovation Journal, 8*(1), 21-30.

Doğantan, A. (2020). Enhancing understanding through interactive instruction models: The role of role-play in distance education. *International Journal of Educational Research, 102*, 101-115.

Gupta, A., Kumar, A., & Singh, R. (2020). Enhancing student engagement through role-playing in system design education. *International Journal of Information Systems and Project Management, 8*(1), 5-18.

Jiang, H., Liu, Y., & Zhang, Q. (2021). The significance of feedback and reflection in role-playing exercises for promoting deeper learning. *Educational Psychology Review, 33*(2), 345-367.

Kerr, R., Smith, J., & Brown, L. (2021). Role-playing exercises as a tool for developing critical thinking and problem-solving skills in students. *Teaching in Higher Education, 26*(4), 453-469.

Liao, Y., Chen, Y., & Huang, T. (2022). Enhancing communication and teamwork skills through collaborative learning activities: The role of role-playing. *Journal of Educational Psychology, 114*(1), 78-90.

Shilton, K., Sayles, S., & Kauffman, L. (2020). Designing for participation: The role of role-playing in system design. *Proceedings of the ACM on Human-Computer Interaction, 4*(CSCW3), 1-24.

Zhao, X., Li, J., & Wang, H. (2022). Student satisfaction with learning experiences: The role of role-playing exercises in education. *International Journal of Educational Management, 36*(5), 789-802.

Zainuddin, Z., & Halili, S. H. (2016). Flipped classroom research and trends from different fields of study: A review. *International Review of Research in Open and Distributed Learning, 17*(3), 313-340.

Uncovering the Story of Earth's Formation Through Treasure Hunt Activities

Mazuin Jasamai*, Mazlin Idress, Zuraini Ismail, Hilmayeni Suardi
Universiti Teknologi PETRONAS, Malaysia
*mazuin_jasamai@utp.edu.my

Introduction

Experiential learning through treasure hunt is a practical educational approach that allows students to engage with real-world experiences actively, fostering a more profound understanding and retention of knowledge (Foo & Foo, 2022).

Objectives

The UTP Geological Rock Garden, a carefully curated outdoor facility that showcases various rock types and geological features, provides an ideal setting for immersive learning. The primary objective of the treasure hunt is to engage 100 students in an active learning experience that challenges them to apply their theoretical knowledge in a practical context. The activity is designed to achieve the learning outcome to describe the processes forming the geological basin and depositional environment, including geologic structures and mechanical deformation. By incorporating elements of game-based learning, the treasure hunt aims to motivate students, enhance teamwork, and encourage critical thinking.

Theoretical Framework

Definition of Experiential Learning

Experiential learning is an educational approach that emphasises learning through direct, hands-on experiences and active engagement with real-world situations, problems, or activities. It is a learner-centred approach that encourages students to actively participate in their learning process, gain practical knowledge, and develop skills by doing, reflecting, and applying what they have learned.

Key Principles of Experiential Learning

David A. Kolb is a psychologist and educator known for his influential theory on experiential learning. Kolb's theory, often referred to as the Experiential Learning Theory or the Kolb Learning Style Inventory (LSI), is based on the idea that learning is a cyclic process that involves four key stages or modes. These stages are often continuous, highlighting how learners engage with and process experiences (Healey & Jenkins, 2000).

Experiential learning is widely recognised for promoting more profound understanding, knowledge retention, and practical skills and competencies development. It encourages active engagement, critical thinking, problem-solving, and the ability to transfer learning to new contexts. This approach is often used in various educational settings, including classrooms, outdoor education, vocational training, and professional development programs (Campbell & Gedat, 2021).

Benefits of Experiential Learning

Experience learning offers numerous benefits for learners of all ages and across various

educational and professional settings. Learners are actively involved in hands-on experiences, making learning more engaging and enjoyable. Experiencing and doing things can lead to better retention of knowledge and skills compared to passive learning methods. Experiential learning promotes critical thinking and problem-solving skills as learners analyse and reflect on their experiences. Experiences create lasting memories, making learners more likely to remember and apply what they have learned over time. Experiential learning prepares individuals for the challenges and demands of the real world, including the workforce. The reflection component of experiential learning encourages learners to think critically about their experiences and make informed decisions. Learners report higher satisfaction with experiential learning experiences than traditional classroom-based learning. Experiential learning fosters a mindset of lifelong learning, encouraging individuals to continue seeking new experiences and knowledge throughout their lives. These benefits make experiential learning valuable in education, training, and personal development, as it promotes holistic and meaningful learning experiences.

Maximising the Treasure Hunt Activity

Pre-Treasure Hunt Preparation

The treasure hunt is a team-based activity, with students divided into groups of 10. Each team is provided clues that lead them to various locations within the Geological Rock Garden. These clues are designed to prompt students to identify and analyse different geological features, such as sedimentary layers, fault lines, and rock formations indicative of specific depositional environments and tectonic activities. They are instructed to take group photos at the rock sample and upload their answer in the form provided. Before the event, students receive a brief orientation on the Geological Rock Garden's layout and the types of geological features they might encounter. It includes an overview of the key concepts in geological basin formation and sediment deposition and identifying structural features such as folds, faults, and fractures. Students are also introduced to the rules of the treasure hunt and the assessment criteria, which emphasise the correct identification of geological features and the ability to articulate the processes that led to their formation (Lazar et.al, 2018).

During the Treasure Hunt

During the treasure hunt, students actively engage in learning and discussion, making the experience as meaningful as possible. The treasure hunt begins with each team receiving a map of the Geological Rock Garden and their first clue. The sequential clues require teams to solve each to progress to the following location. For example, a clue might direct students to a specific rock outcrop where they must identify evidence of sedimentary layering and explain the depositional environment that could have led to such formations. Another clue might lead them to a visible fault line, prompting a discussion on the type of stress that caused the mechanical deformation. The clues are strategically designed to cover various geological processes to meet all learning objectives. Students performed group discussions while identifying the dip direction, dip angle, and strike angle. These activities provide students with an understanding of the geological orientation of the rock layers (Nord & Mattietti, 2013). The strike refers to the compass direction of a horizontal line on the inclined bedding plane, while the dip indicates the angle at which the bedding plane slopes downward from the horizontal.

Post Treasure Hunt Reflection and Assessment

After completing the treasure hunt, students reconvene for a debriefing session where each

team presents their findings. This session is crucial for reinforcing the learning objectives and allowing students to reflect on their experiences. The presentations are assessed based on the accuracy of geological feature identification, the depth of understanding of the processes involved, and the ability to communicate their findings effectively (Villeneuve, M. C,2015). The assessment criteria also include teamwork and problem-solving skills, which are essential competencies in petroleum exploration. The debriefing session concludes with feedback from instructors, who provide additional insights into the geological features encountered and correct any misconceptions.

Conclusion

Uncovering the Story of Earth's Formation Through Treasure Hunt Activities represents successfully integrating immersive learning techniques into teaching fundamentals of Petroleum Exploration Engineering concepts. By leveraging the natural resources of the UTP Geological Rock Garden, this activity provides students with a unique opportunity to apply theoretical knowledge in a practical setting, thereby deepening their understanding of geological processes McCarthy (2010). The positive outcomes of this initiative suggest that immersive learning strategies are adaptable to geoscience education. As petroleum exploration continues to evolve, educational institutions must adopt innovative teaching methods that prepare students for the industry's complexities. This treasure hunt serves as a model for how experiential learning can achieve specific educational outcomes while also making the learning process more engaging and enjoyable for students. Future iterations of this activity could incorporate more advanced technological tools, such as AR or VR, to further enhance the immersive experience. Additionally, expanding the scope of the treasure hunt to include more complex geological scenarios or integrating it with other courses could provide a more comprehensive learning experience. Ultimately, the goal is to equip students with the knowledge and skills they need to succeed in the dynamic and challenging field of petroleum exploration.

References

Campbell, Y. M., & Gedat, R. (2021). Experiential Learning through Field Trips: Effects on Educational, Social and Personal Development among Linguistics Majors. *Journal of Cognitive Sciences and Human Development, 7*(2), 131-144

Foo, S. C., & Foo, K. K. (2022). Purposeful Field Trip: Impact on Experiential Learning Opportunities and Critical Thinking Skills. *Pertanika Journal of Social Sciences & Humanities*, *30*(1).

Healey, M., & Jenkins, A. (2000). Kolb's experiential learning theory and its application in geography in higher education. *Journal of Geography*, *99*(5), 185-195.

Lazar, K. B., Moysey, S. M., Brame, S., Coulson, A. B., Lee, C. M., & Wagner, J. R. (2018). Breaking out of the traditional lecture hall: Geocaching as a tool for experiential learning in large geology service courses. *Journal of Geoscience Education, 66*(3), 170-185.

McCarthy, M. (2010). Experiential learning theory: From theory to practice. *Journal of Business & Economics Research (JBER), 8*(5).

Nord, J., & Mattietti, G. K. (2013, September). Assessment of Capstone Geology Mapping Course: Outdoor, Experiential Learning. *Innovations in Teaching & Learning Conference Proceedings* , 5. Doi:10.13021/G8C896

Villeneuve, M. C., Zimmer, V. L., Eggers, M. J., Bell, D. H., Davies, T. R., & Pettinga, J. R. (2015). *Engineering Geology Education for the 21st Century*. https://ir.canterbury.ac.nz/server/api/core/bitstreams/284be4a2-281a-45dc-801b-8ce640241127/content

From Rig Operations to Classrooms: Storytelling in Geoscience Education

Mohamed M Abdo Aly Elsaadany*, Numair Ahmed Siddiqui, John Oluwadamilola Olutoki
Universiti Teknologi PETRONAS, Malaysia.
*mohamed.elsaadany@utp.edu.my

Introduction

The student's final year project (FYP) and internship always motivated the authors to tell the students as soon as possible about real-world applications of what the students were taught (concepts and terminologies) and opportunities in the oil and gas industry. The challenge for students nearing their future FYP and internships in geoscience education is frequently translating complex, real-world scenarios into understandable and relatable content. While effective in conveying theoretical knowledge, traditional teaching methods do not always fully engage students or communicate the material's practical significance. Storytelling, which is based on oral communication traditions, provides a compelling alternative. By sharing stories from rig operations and seismic interpretation, educators can create a more engaging and memorable learning experience that connects students to the practical applications of their studies.

Storytelling

Storytelling can be defined as using narratives as a communication tool to value, share, and capitalise on individuals' knowledge (Serrat, 2017). Stories have been told orally for centuries to convey encounters and wisdom (Marcus et al., 2012). This tradition is one of human history's oldest knowledge transfer methods, having survived various educational revolutions (Ransome, 1969) and diverse human cultures (Zipes, 2012).

Storytelling in Geoscience

In Earth science, storytelling uses specific plots, such as cause-and-effect, genesis, and destruction — to report and interpret scientific results. These plots, which differ from literary or moral storytelling, reflect the dynamics of Earth's systems. Recognising and using these plots can help resolve scientific controversies and improve communication and interpretation of scientific findings (Jonathan, 2012).

Geoscientists are urged to engage the public by framing geological knowledge within compelling narratives and popular media themes. Effective communication focuses on broader context and cultural relevance rather than facts, aiming to build a positive public image of Earth science (Iain & Ted, 2013).

Geological storytelling is a new graphical tool that simplifies and speeds up geomodeling by allowing geologists to sketch and animate geological models. It helps explore different models and communicate complex geological processes through illustrative 3D animations. Experts find it useful for model development and public communication (Endre et al., 2013).

Fossil content in building stones is used to teach geological concepts through storytelling in Poznań, Poland. The project includes visual guides, museum exhibits, and workshops to enhance public understanding of Earth's history and climate change, addressing misconceptions and planning to expand to other cities (Wolniewicz, 2019).

Storytelling enhances Geoscience education by boosting student engagement and curiosity. A study showed that using a narrative about Mary Anning effectively increased students' interest and motivation in learning about Geosciences, highlighting storytelling as a valuable teaching strategy (Isabel et al., 2023)

Problem Statement

The disconnect between theoretical learning and practical application in geoscience education can cause students to struggle to understand the significance of their studies. Traditional methods of teaching complex topics, such as rig operations and the year one Principles of Stratigraphy course, frequently lack the contextual richness required to engage students fully. This study aims to close this gap by investigating how storytelling can improve the educational experience, making complex concepts more accessible and meaningful.

Objectives

1. To evaluate the effectiveness of storytelling in enhancing student engagement and comprehension in geoscience education.
2. To identify the key elements of successful storytelling that can be applied to teaching rig operations and the Principle of Stratigraphy.
3. To develop a framework for integrating storytelling into geoscience curricula.

Method and Workflow

1. Conduct a literature review on storytelling in education, specifically in STEM fields.
2. Collect stories and experiences from industry professionals regarding rig operations and stratigraphy principles.
3. Curriculum Design: Create lesson plans and educational materials incorporating storytelling while aligning with existing curricula.
4. Implementation: Test the storytelling approach in geoscience classes using quantitative and qualitative methods to determine its impact on student learning.
5. Collect and analyse data from interviews and assessments to assess storytelling's effectiveness in meeting educational objectives.

Participants and Implementation

The study included undergraduate geoscience students enrolled in the Principles of Stratigraphy course. The effect of the lessons behind each story told in class is tested and evaluated through interactive discussion, interviews during and after class, and coursework represented by assignment tests and quizzes. The questions were incorporated into storytelling to achieve the teaching's goals. Industry professionals and educators will work together to create and deliver storytelling-based lessons. The implementation will occur over one academic semester, with regular feedback sessions to refine the approach.

Once Upon a Time Story example: allow the ideas to flow

On the rig and during drilling well "C" in Egypt's Western Desert, it was clear that a few rock strata that should have been penetrated had been missed. During the class, a discussion was started to answer a few questions about how the geologist on the rig discovered the missing section and what the reason(s) could be.

The students begin by explaining how the geologist knows through oral discussion and then attempt to draw their ideas on the whiteboard and persuade the other students of their opinions.

This example was used to teach one of the most critical stratigraphic rules (the law of superposition), rock dating, geological processes (unconformities), and well data correlation (Figure 1).

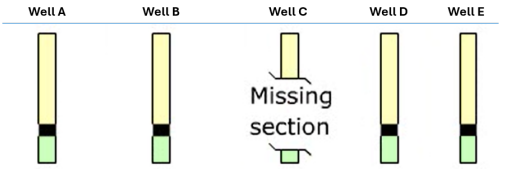


Figure 1 Five wells drilled with a missing section in well C

Results

Preliminary findings show that storytelling significantly increases student engagement, with students demonstrating a better understanding of complex concepts. The narratives added context and relevance, making the material more relatable and easier to remember. The study also emphasises the importance of selecting stories closely related to the educational objectives and the need for educators to be skilled at effectively delivering these narratives. The survey assesses students' engagement, learning preferences, and overall satisfaction with an Earth Science course incorporating storytelling as a teaching method (Figure 2). Here are the key findings,

Varied Prior Knowledge: Students entered with differing levels of familiarity with Earth Science, suggesting a need for foundational material to level-set.

Mixed Extracurricular Engagement: Some students engaged with Earth Science outside of class, while others did not, indicating the potential for more resources or encouragement for independent exploration.

High Likelihood of Continued Interest: Most students expressed a strong interest in continuing to learn Earth Science, showing the course effectively stimulated interest.

Positive Response to Storytelling: Storytelling was rated highly for engagement, helping with complex concepts, and improving information retention, making it a preferred teaching method over traditional approaches like textbooks and lectures.

Effective Learning Activities: The course's hands-on activities were well-received, enhancing understanding and engagement.

Meeting Expectations and High Recommendation Rates: The course met or exceeded expectations for most students, and many would recommend it to peers, indicating an intense overall satisfaction.

Discussion

The results indicate that storytelling effectively teaches Earth Science, enhancing student engagement, understanding, and retention. The positive response to storytelling suggests it may help make complex concepts more accessible and memorable, supporting the effectiveness of narrative-based learning.

The variation in prior knowledge suggests a need for foundational materials to support students with different starting points. Additionally, while many students expressed interest in continuing with Earth Science, lower scores in extracurricular engagement suggest that more resources could encourage learning outside the classroom.

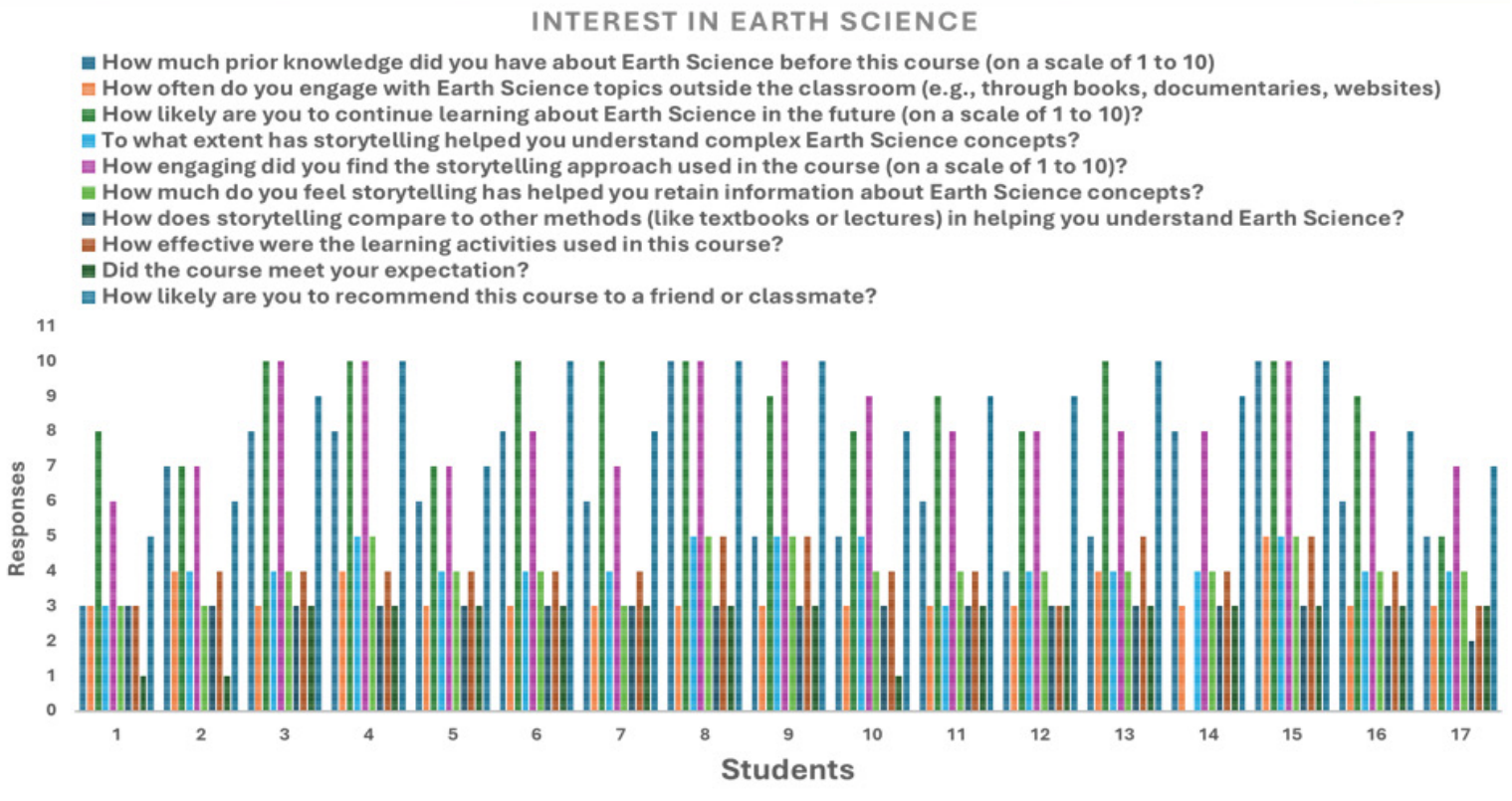


Figure 2 Evaluating the impact of storytelling on Earth Science Learning Outcomes

The course was well-received, meeting expectations and earning high recommendation rates. Expanding storytelling, hands-on activities, and additional resources for independent learning could further improve the course's impact.

Conclusion

In conclusion, storytelling is a powerful educational tool in geoscience, effectively bridging the gap between theory and practical application. The results of this study indicate that students with moderate to high interest in Earth Science experience a significant boost in learning when storytelling is used, while students with lower interest show less impact. Storytelling enhances comprehension and retention, particularly for those already somewhat engaged in the subject. The discussion highlights that while storytelling fosters greater appreciation for geoscience and improves overall engagement, it may need to be supplemented with other teaching methods to capture all students' interests fully. By integrating storytelling into the curriculum, educators can create a more engaging and practical learning experience that helps students connect with Earth science's practical, real-world relevance.

References

Marcus D., Matti T., Carolina I.S., & Erkki S. (2012). Life Planning by Digital Storytelling in a Primary School in Rural Tanzania. *Educational Technology & Society*, *15*(4), 225-237.

Endre M.L., Mattia N., Daniel P., Helwig H., & Ivan V. (2013). Geological storytelling, *Computers & Graphics*, *37*(5), 445-459.

Iain S.S., & Ted N. (2013). Earth stories: Context and narrative in the communication of popular geoscience, *Proceedings of the Geologists' Association*, *124*(4), 619-712.

Isabel T., Dulce L., & Clara V. (2023). Storytelling as an interdisciplinary strategy in Geoscience Education, *International Conference on Education and New Developments Proceeding*, 528-532.

Jonathan P. (2012). Storytelling in Earth Sciences: The eight basic plots, *Earth-Science Reviews*, *115*(3), 153-162.

Ransome, A. (1969). A History of Storytelling. London: ART publications.

Serrat, O. (2017). *Knowledge Solutions: Tools, Methods, and Approaches to Drive Organisational Performance*. Singapore: Springer Open.

Wolniewicz, P. (2019). Bringing the History of the Earth to the Public by Using Storytelling and Fossils from Decorative Stones of the City of Poznań, Poland. *Geoheritage*, *11*, 1827-1837.

Zipes, J. (2012). The Cultural Evolution of Storytelling and Fairy Tales: Human Communication and Memetics". In *The Irresistible Fairy Tale: The Cultural and Social History of a Genre,* Princeton: Princeton University Press, pp. 1-20. Doi:10.1515/9781400841820.1.

Blended Learning in Engineering Mathematics I Integrated Mathematical Thinking and Creative Problem-Solving

Zazilah May*, Dennis Ling Chuan Ching
Universiti Teknologi PETRONAS, Malaysia
*zazilah@utp.edu.my

Introduction

The blended learning approach leverages both face-to-face and digital components to address the needs of students in a mathematics course typically covering foundational concepts necessary for engineering studies. Blended learning in Engineering Mathematics 1 integrates mathematical thinking and creative problem-solving. It allows flexibility where students can access online resources anytime, allowing them to review content as needed and learn at their own pace. In addition, it can enhance engagement through interactive online tools and resources that can make learning more engaging and offer diverse ways to explore mathematical concepts.

Blended learning allows personalised learning where students can focus on areas where they need more practice, and instructors can track progress and provide targeted support based on online activity. Blended learning allows supplementary resources from online platforms, such as interactive simulations, to help illustrate complex mathematical concepts in practical engineering contexts.

Literature Review

Blended learning is a teaching approach that integrates the best classroom practices with various technological applications (Akbarov et al., 2018; Volchenkova & Bryan, 2016).This procedure requires an adequate interaction environment involving direct or remote communication for students to use different learning styles (Santikarn & Wichadee, 2018). Improving learning methods is achievable if teachers overcome their resistance to digital technology and prefer face-to-face interaction over the benefits of online or blended learning (Jeffrey et al., 2014). Teachers should proactively embrace the responsibility to redesign courses with a b-learning approach, offering students a richer and more varied learning experience than what is available through online or traditional classroom settings alone.

Bloom's taxonomy (Bloom, 1956) classifies the achievement of educational objectives at six levels: knowledge, understanding, application, analysis, synthesis, and evaluation. It is well-suited for designing mathematics learning activities for engineering students. For instance, analysing a system's dynamics or phenomena with ordinary differential equations (ODEs) requires a solid grasp of ODE characteristics and key aspects. A blended learning environment, which combines remote and classroom activities, is ideal. The challenge lies in finding the most effective strategies and activities to achieve the educational objectives for each specific situation.

Research Methodology

The blended learning is conducted for 223 Engineering Mathematics 1 students in the May 2024 semester in Universiti Teknologi PETRONAS, Malaysia. The following are descriptions of how blended learning is carried out:

Step 1: Lecturer to choose topics for blended learning: Vector, Dot Product, Cross Product, Gradient

Step 2: The lecturer will attach lecture notes and exercises on selected topics for students to go through and practice: Vector, Dot Product, Cross Product, Gradient

Step 3: The lecturer is to attach a few online videos on the selected topics: Videos on Dot and Cross Product Explanation, Real Word Application of Dot Products, Real World Application of Cross Product, Parallel and Orthogonal Vectors, Area of Parallelogram, Gradient and changes in 3 Dimensions

Step 4: The lecturer will provide a project to be assessed for students to complete: Design a solar farming station subjected to the gradient of the targeted location and the vector of sun rays. Explain the importance of rotating solar panels in harvesting green energy (Electricity). Students are expected to form a group of 4 to 5 members. They must explain the design with diagrams, sentences, and mathematical equations with a few sample calculations.

Results and Discussions

Feedback from the survey indicated that students were comfortable with the proposed activities and work dynamics. The following responses offer insights for improving the design of this educational proposal for future use.

Question 1: Describe the interaction or collaboration in your team when carrying out these activities.

Responses:
"Collaboration was excellent; each person did what they had to do, and there was a lot of chemistry since my partner and I have known each other for a long time; that is why I feel that everything went just fine."
"There was adequate cooperation and collaboration when we carried out the tasks; we agreed on ideas and made everybody's work easier."
"The communication with my partner was excellent; we both contributed equally to the task."

Question 2: What do you think about the material provided to solve your task?

Responses:
"Very useful to solve the problem and acquire the right solution with the right tools to understand the subject better."
"After researching different sources, we could completely satisfy our doubts and clear up any issues that came our way."

Question 3: Describe the difficulties you had during this activity
Responses:
"The most difficult thing was to design with a correct gradient."
"Better understand the relationship between the variables."
"Implement the script in Matlab to provide a numerical solution."

Question 4: Does blended learning help you to understand the topics better?

Responses:
"The lecture notes, supporting related online videos, and examples of real application assist me in understanding the topics better, and we can relate it to the real application."

"We find this blended learning more interesting than normal face-to-face lecture as we can develop our communication, critical thinking, and teamwork skills."

Conclusion

Active methodology, such as blended learning, is an effective tool for advancing research in mathematics education, improving educational processes, and significantly enhancing knowledge acquisition among engineering students. Implementing a well-designed experimental setup to systematically analyse and observe interactions in both classroom and virtual learning environments is crucial. Utilising Bloom's cognitive domain levels in designing learning activities proved effective for organising content and varying difficulty levels. Educators can enhance their courses by incorporating the benefits of blended learning. However, developing practical activities and materials is challenging while balancing online and face-to-face interactions. Students can leverage multimedia tools and digital technologies to activate diverse learning styles in blended courses. Educational institutions should continue to evaluate how integrating technology into educational processes improves active learning.

References

Akbarov, A., Gönen, K., & Aydogan, H. (2018). Students' Attitudes toward Blended Learning in EFL Context. *Acta Didact. Napoc. , 11*, 61–68.

Bloom, B.S. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals*, 2nd ed.; Longman: New York, NY, USA.

Jeffrey, L.M., Milne, J., Suddaby, G., & Higgins, A. (2014). Blended Learning: How Teachers Balance the Blend of Online and Classroom Components. *J. Inf. Technol. Educ. Res., 13*, 121–140.

Santikarn, B. & Wichadee, S. (2018). Flipping the Classroom for English Language Learners: A Study of Learning Performance and Perceptions. *Int. J. Emerg. Technol. Learn., 13,* 123.

Volchenkova, K., & Bryan, A. (2016). Blended Learning: Definition, Models, *Implication for Higher Education. Educ. Sci. 8,* 24–30.

Enhancing Graduates' Employability Skills Via Industrial Training: An Employer's Perspective

Noor Hilyati Alilah, Nurul Naim Ahmad Rasli, Nor Hafizah Abdul Latif Khan
Universiti Sultan Azlan Shah, Malaysia.
noorhilyati@usas.edu.my

Introduction

At a time when colleges and universities are anxious to prove that their graduates are employable, industrial training is increasingly touted as a valuable 'high-impact' practice. According to Aljumah (2023), job training benefits graduates' inclination to work and their chances of securing employment. Graduates who have completed industrial training always demand less initial training and supervision. Finch et al. (2022) stated that this leads to decreased business onboarding expenses and enables faster assimilation into the employment demand.

The contemporary discussion about improving university teaching and learning has centred on whether graduates are fit with the adequate competencies and skills to prepare them for workplace challenges and reality. This research examines strategies for optimising industrial training to boost student-centred learning and graduates' employability abilities, as perceived by employers. This study seeks to get insights into employer attitudes and experiences to inform the establishment and enhancement of industrial training. The purpose of this paper is to outline the objectives,

1. To identify the employability skills employers value in the current job market.
2. To assess the employability skills required by the employer when carrying out industrial training
3. To analyse employer perceptions and expectations regarding the readiness of graduates equipped through industrial training.

Literature Reviews

Graduates Employability Skills

Several researchers have emphasised that employability skills encompass achievements, understanding, and personal attitudes or qualities that distinguish individuals as more capable of securing desired jobs and achieving success in their chosen careers (Nooriah et al., 2013; Md. Shamsuri & Izzaidin, 2014; Morshidi et al., 2012; Noor Suhailie, 2013). In addition, Lim et al. (2016) agree that in order to be employed, an attitude is as important as hard and soft skills. Employability skills are essential educational components that prepare students to meet the diverse needs of the labour market after graduation.

Industrial Training/Internship

Industrial training is a form of experiential learning that integrates knowledge and theory learned in the classroom with practical applications and skills development in a professional setting. Internships allow students to gain valuable applied experience and make connections in professional fields

they are considering for career paths; they also allow employers to guide and evaluate talent. (NACE, 2018). In addition, internships are seen to provide students with improved graduate employment opportunities (Hergert, 2009), improved professional skills (Orrell, 2011; Maertz et al., 2014; Smith & Worsfold, 2015), as well as the opportunity to assess their suitability for their chosen career (Rothman & Sisman, 2016).

Employer Preferences

According to Tapper (2004), employers look for recent graduates who can apply their analytical ability to the workplace upon entering the professional workforce. The research conducted by Hussin et al. (2021) compared teamwork skills, which ranked first, and critical thinking and problem-solving abilities, which ranked lower. On the other hand, employers rate critical thinking and problem-solving abilities as the most crucial, according to NACE (2018).

Methodology

The research targets firms with prior experience recruiting graduates from industrial training in USAS. The population of interest for this research consists of 102 employees from various fields who have employed graduates during the last three years.

The questionnaire has two major sections: Demographic Information: This part gathers background information on respondents and their organisations, such as name, position, email, and organisation address, as well as the perceived value of employability abilities. This section contains Likert-scale questions that assess employers' perceptions of the value of generic skills, soft skills, knowledge, personality, digital literacy, information literacy, and particular employability abilities. The acquired data was analysed using the statistical program SPSS. This research uses inferential statistics to investigate the correlations between variables. Techniques such as correlation analysis and multiple regression have been used depending on the kind of data.

Results and Discussion

The analysis involved computing Pearson correlation coefficients to assess the strength and direction of these relationships. The Pearson correlation coefficient (r) may be used to quantitatively measure a linear connection between two continuous variables. This aids in comprehending the relationship between the changes of one variable and another. The key findings are summarised based on the objectives, as shown in Figures 1 to 7.

Table 1 shows the results for generic skills. The correlation analysis indicates that generic skills have a strong positive relationship with employee preferences, as evidenced by a Pearson correlation coefficient of 0.419. This significant correlation ($p < 0.01$) suggests that improvements in generic skills, such as problem-solving, communication, and teamwork, are strongly associated with enhanced employee job attribute preferences.

Table 1 Results for Generic Skills

		GENERICSKILLS	employeepreferences
GENERICSKILLS	Pearson Correlation	1	.419**
	Sig. (2-tailed)		0
	N	102	102
employeepreferences	Pearson Correlation	.419**	1
	Sig. (2-tailed)	0	
	N	102	102

**. Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 2 the results of knowledge have a moderate positive correlation with employee preferences, with a Pearson correlation coefficient of 0.396. The significance of this correlation ($p < 0.01$) indicates a reliable relationship.

Results of soft skills shown in Table 3 demonstrate a moderate positive correlation with employee preferences, with a Pearson correlation coefficient of 0.309. This statistically significant correlation ($p < 0.01$) implies that employees with better soft skills, such as emotional intelligence, adaptability, and interpersonal skills, have higher job preferences.

Table 4 shows the results of personality traits positively correlated with employee preferences, as indicated by a Pearson correlation coefficient of 0.314. This significant correlation ($p < 0.01$) suggests that personality characteristics, such as openness, conscientiousness, extraversion, agreeableness, and emotional stability, are positively associated with employee job preferences.

Digital literacy exhibits a weak to moderate positive correlation with employee preferences, with a Pearson correlation coefficient of 0.269, as shown in Table 5. Although this is the lowest correlation among the variables, it is still statistically significant ($p < 0.01$).

Information literacy shows a moderate positive correlation with employee preferences, with a Pearson correlation coefficient of 0.338 as shown in Table 6. The significance level (I < 0.01) confirms that this relationship is statistically reliable.

Table 2 Results for Knowledge

Correlations			
		knowledge	employeepreferences
knowledge	Pearson Correlation	1	.396**
	Sig. (2-tailed)		0
	N	102	102
employeepreferences	Pearson Correlation	.396**	1
	Sig. (2-tailed)	0	
	N	102	102
** Correlation is significant at the 0.01 level (2-tailed).			

Table 3 Results for Soft Skills

Correlations			
		softSKILLS	employeepreferences
softSKILLS	Pearson Correlation	1	0.309**
	Sig. (2-tailed)		0.002
	N	102	5
employeepreferences	Pearson Correlation	0.309**	1
	Sig. (2-tailed)	0.002	
	N	102	102

Table 4 Results for Personality

Correlations			
		employeepreferences	personality
employeepreferences	Pearson Correlation	1	0.314**
	Sig. (2-tailed)		0.001
	N	102	102
personality	Pearson Correlation	0.314**	1
	Sig. (2-tailed)	0.001	
	N	102	102

Table 5 Results for Digital Literacy

Correlations			
		employeepreferences	digitalliteracy
employeepreferences	Pearson Correlation	1	0.269**
	Sig. (2-tailed)		0.006
	N	102	102
digitalliteracy	Pearson Correlation	0.269**	1
	Sig. (2-tailed)	0.006	
	N	102	102

Table 6 Results for Information Literacy

Correlations			
		employeepreferences	infoLiteracy
employeepreferences	Pearson Correlation	1	0.338**
	Sig. (2-tailed)		0.001
	N	102	102
infoLiteracy	Pearson Correlation	0.338**	1
	Sig. (2-tailed)	0.001	
	N	102	102

Table 7 Results for Multiple Regression

		unstandardised Coe	Standardi			
		B	Std error	beta		Sig.
Model	(constant)	15.006	6.638		2.264	0.026
	SOFTSKILL	-0.401	0.037	-0.209	-1.085	0.281
	PERSONALITY	0.43	0.468	0.156	0.918	0.361
	DIGITALLITERACY	-0.206	0/307	-0.1	-0.649	0.518
	INFOLITERACY	-0.055	0.453	-0.026	-0.123	0.903
	KNOWLEDGE	0.744	0.507	0.285	1.468	0.145
	GENERICSKILLS	0.575	0.244	0.349	2.36	0.02

As the results in Table 7.0, among the six variables, Generic Skills has the most significant effect on the dependent variable (Employer Prefer) as it has the highest standardised coefficient ($\beta = 0.349$) and a significant p-value ($p = 0.020$). Knowledge also shows a positive effect but is not statistically significant in this model. The other variables (Soft skills, Personality, Digital Literacy, Info Literacy) do not significantly affect the dependent variable in this context.

Conclusion

Our findings contribute insights into the most critical preferable skills from the employer's view. These findings also indicate that higher education professionals, policymakers, and workforce educators who discuss internships should become more attentive to student marketability, experience, and needs. Additional research that explicitly examines the assessment of skill deficiencies, the influence of industrial training duration and program design, and the significance of collaboration between academia and industry can offer a thorough understanding of how industrial training improved the graduates' employability skills from an employer's standpoint.

References

Aljumah, A. (2023). The Impact of Job Training on Recruitment and Employability Skills Among Graduates. *International Journal of Professional Business Review*, 8(10), e2806.

Finch, D. J., Hamilton, L. K., Baldwin, R., & Zehner, M. (2022). An exploratory study of factors affecting undergraduate employability. *Journal of Education and Training, 64(2),* 162-178.

Hergert, M. (2009). Student Perceptions Of The Value Of Internships In Business Education. *American Journal of Business Education (AJBE)*, *2*(8), 9-14. Doi:10.19030/ajbe.v2i8.4594

Hussin, M., Estiar, N., Ahmad, A. R., & Rahim, H. (2021). Competency Level of Communication, Creative Thinking and Problem Solving among Tertiary Students. International *Journal of Academic Research in Progressive Education and Development, 10(3),* 1375-1384.

Lim, Y.M., Lee, T.H., Yap, C.S., & Ling, C.C. (2016). Employability skills, personal qualities, and early employment problems of entry-level auditors: perspectives from employers, lecturers, auditors, and students. *J. Educ. Bus. 91 (4),* 185-192.

Maertz, Carl., P, Stoeberi, Philips.,P & Marks, J. (2014). Building successful internships: Lessons from the research for interns, schools, and employers. *Career Development International, 19(1)*. Doi::10.1108/CDI-03-2013-0025

Md. Shamsuri, M.S. & Izzaidin, A.M. (2014). Employers' perceptions of important employability skills required from Malaysian Engineering and Information and Communication Technology (ICT) graduates, *Global Journal of Engineering Education, 16(3), 110-115.*

Morshidi, S., Chan, L. H., Munir, S., Shukran, A. R., Seri Rahayu, A. K., Kaur, J. & Singh N. (2012). Graduate employability in Malaysia in Graduate employability in Asia, UNESCO: Bangkok, 24-37

National Association of Colleges and Employers, NACE (2018).https://www.naceweb.org/conferenceexpo/files/2018/2018-nace-conference-program.pdf

Nooriah, Y., Zakiah, J. & Norain, M. L.(2013). Persepsi pelajar prasiswazah terhadap kebolehpasaran graduan dan persaingan dalam pasaran pekerjaan. *Jurnal Personalia Pelajar, 16*, 77-92.

Noor Suhailie, M.N. (2013). Higher Education and Graduates Employability Skills: What The Employer Think and Graduates Have?, Master of Development Policy, KDI School of Public Policy and Management.

Orrell, J (2011). *Good Practice Report: Work-integrated Learning,* Office Australian Learning and Teaching Council, Sydney.

Rothman, M., & Sisman, R. (2016). Internship impact on career consideration among business students. *Education & Training, 58(9)*, 1003-1013. Doi:10.1108/ET-04-2015-0027

Smith, C. & Worsfold, K. (2015). Unpacking the learning–work nexus: 'priming' as lever for high-quality learning outcomes in work-integrated learning curricula, *Studies in Higher Education, 40*(1), 22-42.

Tapper, J. (2004). Student perceptions of how critical thinking is embedded in a degree program. *Higher Education Research & Development 23(2),* 199-222. Doi:10.1080/07294360420006663.

Inquiry-Based Learning on Engineering and Science Students: A Review

Syed Muhammad Yasir Ashrafi*, Wesam Salah Alaloul, Muhammad Ali Musarat
Universiti Teknologi PETRONAS, Malaysia
*syed_24000943@utp.edu.my

Introduction

Students actively participate in inquiry-based learning by posing questions and receiving practical experiences. By utilising questions to guide students' thought processes, this technique aims to help them learn "how to think" rather than "what to think". Through inquiry-based learning, students are steered towards critical thinking. It requires self-control, reasoning, synthesised justification, analysis, and assessment. Critical thinking is necessary in higher education, especially academic writing, to help students become better communicators, problem solvers and decision-makers. Critical thinking can be included in the teaching and learning process to accomplish this (Keselman, 2003; Hilsdon, 2010; Facione, 2011). Improving the fundamental critical thinking abilities of self-control, inference, analysis, assessment, and interpretation is encouraged via inquiry-based learning, enhancing students' critical thinking abilities (Hilsdon, 2010; Facione, 2011). Science curricula, international research and development initiatives, and instruction are all seeing an increase in the use of inquiry-based learning. One of the fundamental causes is that recent technological advancements that enable electronic learning environments to enhance the inquiry process can significantly increase its success (Pedaste et al., 2015). Students participate in inquiry-based learning to produce knowledge by employing methods and strategies similar to those of working scientists (Keselman, 2003). It can be defined as an activity where learners create hypotheses and verify them through experiments and/or observations to discover unique fundamental connections. (Pedaste et al., 2012). It is commonly considered a problem-solving method that uses multiple problem-solving strategies (Pedaste & Sarapuu, 2006). In the modern era of technology and information, where scientific knowledge is expanding daily, and technological advancements are happening quickly, It is clear that education in science and technology is essential. For the future of societies, science and technology have a noticeable impact on every part of our lives (Karamustafaoğlu, 2010).

Most of the knowledge of science and engineering students is practical, meaning students must gain analytical skills, involvement in the class, ask questions at the moment, provide responses, and get feedback. Inquiry-based learning (IBL) can fulfil all these requirements because it is a teaching method that relies on students' participation rather than traditional teaching methods. IBL can be implemented in various ways in engineering and science. It is essential to discuss how it can be implemented, how it can be implemented, and what the advantages would be if it were implemented.

Literature Review

The student body benefits significantly from active learning pedagogies regarding

higher-order cognitive skills development (Madhuri et al., 2012). Science, technology, engineering and mathematics (STEM) have long embraced inquiry-based learning as a teaching strategy. Still, more research should be done on the practice of engineering education (Luo et al., 2023).

The growth of creativity and invention is one of the learning goals of engineering education. Engineers must offer technical solutions for contemporary and emerging social and technological problems. Designing teaching-learning environments with inquiry-based learning as a guiding concept can help students acquire key interdisciplinary and professional competencies (Mieg, 2019). When beginning an engineering degree program, students are sometimes confronted with competing expectations: "achievement in the core engineering subjects, along with short study periods, study abroad opportunities, soft skills, and economic acumen" (Becker, 2007). The IBL process, often referred to as the learning cycle (Kolb, 2014) or the research cycle (Jungmann, 2019), is depicted in Figure 1 in engineering programs.

Figure 1 represents the IBL process that has been divided into four steps, which are,

1. Concrete Experience: This level describes students' interactions with people in day-to-day settings. When faced with concrete circumstances, Students are more prone to depend on their feelings, be open-minded, and be flexible than they are to approach situations and issues methodically.
2. Reflective Observation: At this point, students can see concepts and circumstances from several angles. They are more dependent on perseverance, objectivity, and cautious appraisal than on really doing anything. Based on their ideas and emotions, students form opinions.
3. Abstract Conceptualisation: Instead of understanding events or situations through interpersonal concerns or sentiments, learners up to this point understand them by putting ideas, logical procedures, and concepts into practice. They usually rely on methodical theories and concepts related to planning and constructing to solve difficulties in the real world.
4. Active Experimentation: When students are actively engaged, they are experimenting with different situations to show that learning is an active process. Instead of only seeing a scenario, students engage in hands-on learning during the active experimentation stage.

The cycle begins again whenever there is uncertainty or new issues that arise after implementation.

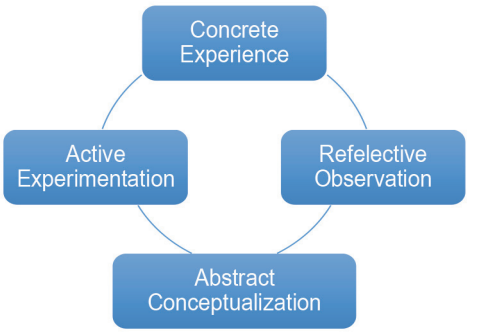


Figure 1 Inquiry-based learning process

Aiming for excellence for all as a nation goes to college, Liberal Education and America's Promise (LEAP) was introduced in 2005 by the Association of American Colleges and Universities (AACU). Intellectual and practical skills comprise one of the four fundamental learning abilities LEAP advises students to achieve (Series et al., 2005). Engineering design, a key field activity, requires applying two critical and creative thinking abilities — inquiry and analysis (Eppes et al., 2020).

Science students employ inquiry to develop ideas and theories to comprehend the realities about nature and their surroundings and explain the factual events they have witnessed like

scientists (Bransford, 2000). Harlen (2004) stated that the emphasis on memorisation in scientific education has given way to inquiry-based scientific learning, which is more focused on teaching the concepts and laws of science than passively observing events through books of ideas and facts to efficiently use critical thinking and scientific processing abilities (Zacharia, 2003). Inquiry-based science learning uses an active, student-centred understanding that encourages students to generate research ideas (Jorgenson et al., 2004).

Numerous scholars have reported that teaching students to conduct scientific research like experts and develop more profound thinking skills through IBL is practical (Bransford, 2000; Bass et al., 2001; Bonner, 2005; Feldman et al., 2012).

Through IBL, students are equipped with the necessary skills to become self-sufficient, lifelong learners and free thinkers (Llewellyn, 2002). An inquiry-based learning approach enhances students' innovative thinking, ability to learn, critical thinking skills and ability to solve problems. (Lawson, 2009). Additionally, a study has found that a strategy based on inquiry-based learning can help students enhance their comprehension of scientific procedures and their knowledge of science (Domjan, 2003).

Models of Engineering

There are three models of engineering that can be implemented.

1. Engineering education uses three pedagogical models: inquiry-based, project-based, and problem-based learning. Two factors may cause readers' confusion: there are a lot of various forms of "-based learning" in the education field, and the exact phrases are used in multiple curricula, including K-12, medical, business, law and engineering. As a result, a large number of study and review articles on learning methodologies have been published (Dym et al., 2005; Pedaste et al., 2015; Savery, 2015)..
2. Project-based learning (PBL) addresses applying information from several disciplines to real-world construction and design challenges. PBL focuses on solving theoretical problems using any pertinent knowledge, regardless of the field from which the knowledge comes.
3. The third model is IBL, which is student-centred and emphasises asking questions and thinking critically (Pedaste et al., 2015).

Justice et al. (2009) envisioned IBL as a learning loop. Figure 1 promotes development and change as the first investigation sparks new questions and interests. The entry points are understanding the collaborative possibilities of knowledge production and taking active responsibility for learning. The search for solutions generates new knowledge through collecting, processing, and reflecting information (Savery, 2015). Success at every level is a result of and driven by self-reflection and review. It has been demonstrated that IBL is a proper pedagogical strategy (Justice et al., 2007) and a crucial way to link research and instruction (Healey, 2005).

Pedaste et al. (2015) identified 109 distinct phases of inquiry-based learning. These rounds were combined to create 34 shortlisted groups, further narrowed to 5 groups. The description of every shortlisted phase can be seen in Table 1. This includes five stages of IBL — orientation, conceptualisation, investigation, conclusion, and finally discussion.

Orientation aims to ignite people's attention and curiosity about the issue. In this stage, the student defines the learning topic, or the teacher introduces the topic (Scanlon et al., 2011). The process of comprehending a notion or concept pertinent to the subject is known as conceptualisation. According to Scanlon (2011) the investigation phase is when curiosity turns into reality, which means learners take some actions related to the targeted problem, research

Table 1 Phases of IBL

Phase	Definition
Orientation	The technique of using a problem statement to address a learning obstacle and pique students' curiosity about a subject.
Conceptualisation	Formulating questions and/or assumptions based on theory.
Investigation	The procedure for organising an investigation or experiment, gathering data, and interpreting it in light of the findings of the investigation or experimental design.
Conclusion	The method by which conclusions are drawn from the facts. contrasting conclusions drawn from data with research questions or hypotheses.
Discussion	The act of regulating the entire learning process or just a few of its phases through reflective activity and/or sharing the results of the phases or the entire inquiry cycle with others.

questions, or hypotheses. The section of a study where the primary conclusions are presented is called the conclusion (De Jong, 2006). In this stage, students address the research questions or hypotheses they came up with and decide whether the study's findings confirm or refute them (White et al., 1999; Scanlon et al., 2011). Many people view the discussion as an inner feeling or inside activity (How did I go about it?? What made me behave in that manner? Had I done enough? What other choices are there in a comparable circumstance?). Activities like playing a role in journaling, narrative writing and asking leading questions can support this process. The outcome of the conclusion phase is a final judgment about the outcomes of inquiry-based learning that responds to the research questions or hypotheses (Runnel, et al., 2013). These can assist students in achieving particular quality standards for their reflections: explanation, rationale, assessment and conversation. (Leijen et al., 2012).

Types of IBL in Engineering and Sciences

Structured, guided and oriented inquiry are the three main types of IBL used in engineering and sciences (Colburn, 2004).

Structured Inquiry
This kind of inquiry involves the teacher selecting the subjects and providing step-by-step instructions for them. This is where the instructor can set boundaries and organise the range of topics and exercises. The teacher decides and provides everything, including the research method, the questions to be answered, and the technique itself (Keller, 2001; Spaulding, 2001).

Guided Inquiry
Some researchers arque that this type of research combines open and organised questions. In this investigation type, the instructor poses the central questions and monitors students' methods responses to them (Spaulding, 2001; Llewellyn, 2002; Tatar, 2006).

Open Inquiry
At this level of inquiry, which is the highest, learners choose the activities and research topics independently and decide what is significant in their subject. Acceptance of it as wholly student-centered exists. Thus, students are personally responsible for their learning during the open inquiry process because they raise questions, plan the investigation, and draw conclusions (Keller, 2001; Llewellyn, 2002; Tatar, 2006; Blanchard et al., 2010).

Difference Between IBL and Traditional Teaching During Laboratory Work

Engineering and science students spend much time in laboratories doing practical work. The difference between traditional teaching

methods and IBL can be depicted in Table 2, and it represents various aspects of education, including objective, student role, instructor role, session structure, evaluation method, contents, and theory and practical integration. Students have developed critical thinking skills by learning STEM topics through IBL activities. These skills include using technical language and laboratory equipment and exploring new ways to apply their knowledge to solve problems (Table 2). These skills typically encourage students to investigate independently and integrate all of their knowledge to solve real-life problems (Yu, 2020). IBL techniques promote knowledge based on practical instead of only relying on academic knowledge, which is the case with traditional methods (Table 2). It also encourages students to learn autonomously, eventually improving their personal learning skills.

Table 2 Difference between traditional and IBL methods

Aspect	**IBL**	**Traditional**	**Difference**
Objective (Freeman et al., 2014)	Enhances critical thinking, problem-solving, and research capabilities.	Teaches particular experimental methods and scientific concepts.	IBL emphasizes the development of more general abilities, whereas traditional laboratories concentrate on particular scientific methods and subjects.
Student Role (Weaver et al., 2008)	Engaging, adopts a researcher's mindset, investigating and probing.	More supervised, conducts tests by predetermined guidelines.	IBL encourages learners to be autonomous, although traditional laboratories take a more regimented approach.
Instructor Role (Walker, et al., 2010)	Facilitator who directs the study process and offers resources and assistance.	The director gives clear directions and examples.	While traditional labs focus on instruction and demonstration, IBL emphasizes guidance throughout the learning process.
Session Structure (Freeman et al., 2014)	Adaptable, dependent on the research methodology.	Organized according to pre-established lab manuals.	IBL permits adaptable investigation, whereas typical labs have a set layout.
Evaluation (Justice et al., 2007; Freeman et al., 2014)	Considering the methods and results of the research (e.g., research reports, presentations).	Based on the correctness of the experimental results and the subsequent procedures.	While standard lab evaluations concentrate on procedural correctness and results, IBL evaluations are more process-oriented.
Content Freeman et al., 2014) (Walker, et al., 2010)	Broader subjects related to actual research.	Concentrates on particular ideas and methods required to comprehend the field.	While traditional labs concentrate on well-established scientific information, IBL interacts with ongoing research.
Theory And Practical Integration (Prince & Felder, 2006; Sponken-Smith, Walker, 2010, Freeman et al., 2014)	Organic and continuing, as learners use abstract ideas to explore actual issues.	Sequential, with theory frequently being covered before being put to use in a lab setting.	IBL encourages theory and practice to interact continuously, whereas traditional laboratories frequently divide these two domains.

Advantages of IBL in Science Education

The following is a list of the main advantages that inquiry-based learning offers,

1. Boosts student performance and facilitates the comprehension of data (Mattheis & Nakayama, 1988).
2. It provides pupils with various options, including gathering, sorting, questioning, and classifying knowledge. (Wilder & Shuttleworth, 2005)
3. Guarantees that the nature of scientific knowledge is understood (Quintana et al., 2010)
4. Pupils gain knowledge by sharing the tools they gathered to address an issue (Wenk, 2000)
5. Increasing students' motivation is an excellent way to use it (Bayram et al., 2013)
6. It is critical to apply creative thinking when reviewing the data and honing analysis and production skills (Vural, 2006)
7. Provides opportunities for social interaction and advanced thinking skills development for pupils (Shih et al., 2010)
8. Students acquire knowledge expectedly. As such, it facilitates the formation of the students' epistemic views (Wilke & Straits, 2005; Shih et al., 2010)
9. It helps students advance their capacity for scientific processing, critical thinking, and problem-solving (Bell et al., 2005; Bybee, 2006; Chung & Behan, 2010)
10. Assists in the advancement of advanced learning abilities (Wilke & Straits, 2005)

The use of inquiry-based learning initiatives has numerous advantages. Among these advantages are the following in Figure 2.

Conclusion

Science curriculum, international research and development initiatives, and instruction are all seeing an increase in the use of inquiry-based learning. One fundamental reason is that technological advancements that make the inquiry process can significantly increase its success. Although inquiry-based learning is not unique, it has recently received much support in science and mathematics education due to its ability to provide the knowledge, skills and attitudes people in an increasingly technologically advanced society need. Inquiry-based learning has various advantages for engineering students. Its application can benefit in many ways.



Figure 2 Advantages of IBL (Gladun & Buchynska, 2017)

Acknowledgement

The authors would like to thank the Universiti Teknologi PETRONAS (UTP) for the support from the (cost centre 015PBC-004) awarded to Wesam Salah Alaloul.

References

Leijen, A., Valtna, K., Leijen, D.A.J. & Pedaste M. . (2011). How to determine the quality of students' reflections? *Studies in Higher Education, 37*(2), 203-217.

Bayram, Z., Özge Ö.O., Emine, E., Sinem, D.Ö., & Şenol Ş., (2013). Effect of inquiry based learning method on students' motivation, *Procedia-Social and Behavioral Sciences, 106,* 988-996.

Becker, F.S. (2007). *Was heute von Ingenieuren verlangt wird. Markttrends*, Erfahrungen von Berufsanfängern, Erwartungen von Personalverantwortlichen und Karrieremechanismen, In Arbeitsmarkt Elektrotechnik Informationstechnik, Berlin: VDE-Verlaq,

Bell, R.L., Smetana, L. & Binns, I. (2005). Simplifying inquiry instruction, *The Science Teacher, 72*(7), 30–33.

Blanchard, M. R., Southerland, S. A., Osborne, J. W., Sampson, V. D., Annetta, L. A., & Granger, E. M. (2010). Is inquiry possible in light of accountability?: A quantitative comparison of the relative effectiveness of guided inquiry and verification laboratory instruction. *Science Education, 94*(4), 577–616.

Bonner, J. J. (2005). Which scientific method should we teach & when? *The American Biology Teacher, 67*(5), 262–264.

Bransford, J. D., Brown A. L. & Cocking, R. R. (2000). *How People Learn: Brain, mind, experience, and school.* Committee on Developments in the Science of Learning, Washington: National Academy Press.

Bybee, R. W. (2006). *Scientific inquiry and science teaching, in Scientific inquiry and nature of Science: Implications for teaching, learning, and teacher education*. Springer, 1–14.

Bass, J. E., Contant, T. L. & Carin, A. A. (2008). *Methods for teaching science as inquiry,* Tenth Edition, London:Pears

Chung, H.-M. and Behan, K. J. (2010). Peer sharing facilitates the effect of inquiry-based projects on science learning, *The American Biology Teacher, 72*(1), 24–29.

Colburn, A. (2004). Inquiring Scientists Want to Know, *Educational Leadership, 62*(1), 63.

De Jong, T. (2006). Technological advances in inquiry learning, *Science, 312(*5773), 532–533. Domin, D.S. (1999). A review of laboratory instruction styles, *Journal of Chemical Education, 76*(4), 543.

Domjan, H.N. (2003). An analysis of elementary teachers' perceptions of teaching science as inquiry. Dissertation, University of Houston.

Dym, C.L., Alice, M.L., Ozgur, E., & Daniel, D.F. (2005). Engineering design thinking, teaching, and learning, *Journal of Engineering Education, 94*(1), 103-120.

Eppes, T., Milanovic, I., & Wright, K. (2020). Improving student readiness for inquiry-based learning: An engineering case study, *International Journal of Online and Biomedical Engineering (iJOE), 16*(01).

Facione, P.A. (2011). Critical thinking: What it is and why it counts, *Insight assessment, 1*(1), 1-23.

Feldman, A., Chapman, A. M., Vernaza-Hernández, V., Dilek O., & Fayez A. (2012).

Inquiry-based science education as multiple outcome interdisciplinary research and learning (MOIRL). *Science Education International,* 23(4), 328-337.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Nnadozie Okoroafor, J. H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. P*roceedings of the National Academy of Sciences, 111*(23), 8410–8415.

Gladun, M., & Buchynska, D. (2017). Tools for inquiry-based learning in primary school, *Open educational e-environment of modern University,* 3, 43–54.

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., Gentile, J., Lauffer, S., Stewart, J., Tilghman, S. M., & Wood, W. B. (2004). *Scientific Teaching. Science, 304*(5670), 521–522.

Harlen, W. (2004). Evaluating inquiry-based science developments. A paper commissioned by the National Research Council in preparation for a meeting on the status of evaluation of Inquiry-Based Science Education, The National Academies, August 31.

Healey, M. (2005). Linking research and teaching to benefit student learning, *Journal of Geography in Higher Education, 29(*2), 183–201.

Hilsdon, J. (2010). Critical thinking: Learning development with Plymouth University.

Jorgenson, O., Cleveland, J., & Vanosdall, R. (2004). *Doing Good Science In Middle School: A Practical Guide to Inquiry-based Instruction,* Richmond: Natl Science Teachers Assn.

Jungmann, T. (2019). Inquiry-based learning in the engineering sciences, Inquiry-based learning–Undergraduate research. T*he German Multidisciplinary Experience,* 205-215.

Justice, C., Rice, J., Warry, W., Inglis, S., Miller, S., & Sammon, S. (2006). Inquiry in Higher Education: Reflections and Directions on Course Design and Teaching Methods. *Innovative Higher Education, 31*(4), 201-214.

Justice, C., Rice, J., Roy, D., Hudspith, B., & Jenkins, H. (2009). Inquiry-based learning in higher education: administrators' perspectives on integrating inquiry pedagogy into the curriculum. *Higher Education, 58*(6).

Karamustafaoğlu, S. (2010). Evaluating the Science Activities Based On Multiple Intelligence Theory, *Journal of Turkish Science Education (TUSED), 7*(1).

Keller, J.T. (2001). From theory to practice creating an inquiry-based science classroom. Pacific Lutheran University.

Keselman, A. (2003). Supporting inquiry learning by promoting normative understanding of multivariable causality, *Journal of Research in Science Teaching, 40*(9), 898–921.

Kolb, D.A. (2014). *Experiential learning: Experience as the source of learning and development*, Second Edition, New Jersey: Pearson FT Press.

Lawson, A.E. (2009). *Teaching inquiry science in middle and secondary schools.* Thousand Oaks: Sage.

Llewellyn, D. (2002). *Inquiry within: Implementing inquiry-based science standards.* Thousand Oaks: Corwinn Press, Inc.

Luo, T., Arcaute, K. & Muljana, P.S. (2023). Integrating inquiry-based learning into engineering education: A case study, *Innovations in Education and Teaching International, 60*(6), 836-847.

Madhuri, G. V, Kantamreddi, V., & Prakash Goteti, L.N.S. (2012). Promoting higher order thinking skills using inquiry-based learning,

European Journal of Engineering Education, 37(2), 117-123.

Mattheis, F.E., & Nakayama, G. (1988). *Effects of a Laboratory-Centered Inquiry Program on Laboratory Skills, Science Process Skills, and Understanding of Science Knowledge in Middle Grades Students*. ERIC Technical Report.

Mieg, H.A. (2019). *Inquiry-based learning-undergraduate research: The German multidisciplinary experience*. Cham. Switzerland: Springer.

Pedaste, M., Mäeots, M., Leijen, Ä., & Sarapuu, T. S. (2012). Improving students' inquiry skills through reflection and self-regulation scaffolds. *Technology, Instruction, Cognition and Learning*, 9(1-2), 81-95.

Pedaste, M., Mäeots, M., Siiman, …, Zacharia, Z. C., & Eleftheria Tsourlidaki. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47-61.

Pedaste, M., & Sarapuu, T. (2006). Developing an effective support system for inquiry learning in a web-based environment, *Journal of Computer-Assisted Learning, 22*(1), 47-62.

Prince, M.J., & Felder, R.M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases, *Journal of Engineering Education, 95*(2), 123-138.

Quintana, C., Zhang, M., and Krajcik, J. (2010). A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding, *Educational Psychologist*, 40(4), 235-244.

Runnel, M.I., Pedaste, M., & Leijen, Ä. (2013). Model for guiding reflection in the context of inquiry-based science education, *Journal of Baltic Science Education, 12*(1), 107.

Savery, J.R. (2015). Overview of problem-based learning: Definitions and distinctions. In W. Andrew, L. Heather, C. Hmelo-Silver, & P. Ertmer (eds.), *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows* (5–15), Indiana: Purdue University Press.

Scanlon, E., Anastopoulou, S., Kerawalla, L., & Mulholland, P. (2011). How technology resources can be used to represent personal inquiry and support students' understanding of it across contexts. *Journal of Computer Assisted Learning, 27*(6), 516–529.

Series, A.T., Davenport, A., &Humphreys, D. (2005). What Really Matters in College How Students View & Value. *Liberal Education, 91*(3), 36-43.

Shih, J.-L., Chuang, C.-W., & Hwang, G.-J. (2010) 'An inquiry-based mobile learning approach to enhancing social science learning effectiveness, *Journal of Educational Technology & Society, 13*(4), 50–62.

Spaulding, D.T. (2001). *Stakeholder perceptions of inquiry-based instructional practices. Doctoral Dissertation*, School of Education, University at Albany State, University of New York.

Spronken-Smith, R., & Walke, R. (2010). Can inquiry-based learning strengthen the links between teaching and disciplinary research?, *Studies in Higher Education, 35*(6), 723–740.

Tatar, N. (2006). The effect of inquiry-based learning approaches in the education of science in primary school on the science process skills, academic achievement and attitude. Doctoral Dissertationn, Gazi University.

Vural, B. (2006) Eğitim-öğretimde planlama-ölçme ve stratejiler. Hayat.

Weaver, G.C., Russell, C.B., & Wink, D.J. (2008). Inquiry-based and research-based laboratory pedagogies in undergraduate science, *Nature Chemical Biology, 4*(10), 577-580.

Wenk, L. (2000). Improving science learning: Inquiry-based and traditional first-year college science curricula. Dissertation, University of Massachusetts Amherst.

White, B.Y., Shimoda, T.A., & Frederiksen, J.R. (1999). Enabling students to construct theories of collaborative inquiry and reflective learning: Computer support for metacognitive development. *International Journal of Artificial Intelligence in Education, 10*, 151–182.

Wilder, M., & Shuttleworth, P. (2005). Cell inquiry: A 5E learning cycle lesson, *Science Activities, 4*1(4), 37-43.

Wilke, R.R., & Straits, W.J. (2005). Practical advice for teaching inquiry-based science process skills in the biological sciences, *The American Biology Teacher,* 534-540.

Yu, W. (2020). A Hands-on Project to Improve Student Learning Experience in Electronics: Building Ship Storage Room Security System, in *2020 IEEE Integrated STEM Education Conference (ISEC). IEEE*, 1-5.

Zacharia, Z. (2003). Beliefs, attitudes, and intentions of science teachers regarding the educational use of computer simulations and inquiry-based experiments in physics. *Journal of Research in Science Teaching, 40*(8), 792-823.

Developing Academic Resilience for Engineering Students through the Application of Flipped Learning

Mysara Eissa Mohyaldinn*
Universiti Teknologi PETRONAS, Malaysia.
*mysara.eissa@utp.edu.my

Introduction

In recent years, academic resilience has grasped the attention of researchers and practitioners of education research across different fields, including engineering education. The rapid dynamic changes in life, the changes in attributes of the current generations compared to previous generations, and the life impact of undesirable incidents and disasters have all necessitated academia to adopt the academic resilience culture to assist learners in adapting to the changes. Resilience is a term in psychological research that describes how an individual can respond to personal stress and advises creating an environment that enables the individual to adapt positively to life's hardships (Rutter, 2012). It is described as a set of characteristics and protective processes that assist the individual to adapt successfully to the current circumstances to overcome undesired, difficult conditions (Gundogan, 2021).

Understanding the right factors to create resilience can enable the individual to overcome threats to positive development (Rudd et al., 2021). COVID-19 is one of the recent undesired circumstances where education resilience has been thought of and adopted by different means to ensure a smooth running of the educational system (Barzilay et al., 2020). Educators and learners must build a reliable and resilient environment in harsh circumstances. During COVID-19, educators have been drastically troubled by the uncertainty and unexpected changes in schooling (Yang et al., 2023). This intensified stress and burnout due to heavy workload, multi-tasking, lack of resources, and accountability pressures (Trinidad, 2021). Educators, on the other hand, can go through difficult times that can cause stress at all levels of study, from primary and up to post-university. This stress can even happen under usual conditions due to accumulated negative emotions such as anger and fear (Yamamoto et al., 2023). The emotional risks associated with the spread of COVID-19, including fear of infection and death, were extensively studied and collectively conceptualised as the "fear of COVID-19" (Ahorsu et al., 2020). It is reported that the fear of COVID-19 negatively impacts human beings of all ages and causes distraction to their mental, behavioral, and cognitive capabilities (Eroglu et al., 2023). Resilience can be used to defeat or minimise the fear of COVID-19, assist the individual in coping with the fear and normalise life during COVID-19 positively. However, the success and efficiency of psychological resilience differs from one person to another, depending heavily on the personality. Students at university belong to a critical and sensitive life stage, making them among those at high risk of adverse impacts due to the fear of COVID-19. This is because they are transitioning from an adolescent development process associated with specific duties while facing social and academic responsibilities inside the university (Eroglu et al., 2023).

Flipped classrooms have been proven to develop students' personalities in many directions. Many researchers have reported the positive impacts of the flipped classroom on students' academic performance and global skills. Therefore, it is believed that the flipped classroom can significantly improve students' educational resilience by enhancing their lifelong learning, motivation, and general development of the learning process (Barrios et al., 2022).

This paper presents a collection of previous experiences implementing flipped classrooms for teaching petroleum engineering core subjects. It discusses the results of the flipped class implementation in terms of features related to academic resilience.

Impact of Flipped Classroom on Students' Academic Resilience Development Via Cognitive Skills and Academic Performance

It is worth noting that the goal of the learning process in tertiary education is to equip students with the knowledge and skills needed to practice the job for which they are educated based on their academic discipline. Whether students have achieved the program objectives and learning outcomes and how they were successful during their study can be assessed by measuring their academic performance. The development of the cognitive domain of students is a top priority to ensure high understanding, digestion, and retention of the information received, as well as proper processing of the data into practical knowledge. We believe the relationship between cognitive skill and academic resilience is interdependent. This means that improving cognitive skills can equip students with a higher level of academic resilience, and developing academic resilience can enhance their mental skills, improving their academic performance. Students from the same background may perform academically differently due to the variation in their academic resilience (Kuldas et al., 2015).

Responses from many students have confirmed the positive impact of flipped classrooms on enhancing cognitive skills such as understanding, critical thinking, and in-depth analysis (Table 1).

Table 1 shows students' responses to the impact of flipped classrooms on their academic resilience development via cognitive skills and academic performance

Response statement	FC #	Remarks
More clear knowledge	2	Higher understanding.
Easy to understand	2	
Ease the understanding for students and familiarise the student with the lecture content flow	3	
Easier to understand	3	
This online [flipped classroom] teaching process had positively impacted teaching without being detrimental to the students (An abnormal focus on finishing tasks, forcing students to complete multiple tasks on multiple different deadlines without any necessity to […]	4	Critical thinking and in-depth analysis.
It gave me a clearer understanding of specific topics and improved my memory power.	4	

References

Ahorsu, D.K., Lin, C.Y., Imani, V., Saffari, M., Griffiths, M.D., & Pakpour, A.H. (2020). The fear of COVID-19 scale: Development and initial validation. *International. J. Ment. Heal. Addict.* 1–9.

Barrios, T.A., Rojas, S.L., Movilla, J.S., Ibáñez, S.F.U., & Taboada, A.H. (2022). Characterisation Of Flipped Classroom Model in Higher Education: A Perception from Educational Resilience During Covid-19 Pandemic. *Procedia Comput. Sci. 203*, 575–582.

Barzilay, R., Moore, T.T., Greenberg, D.M., DiDomenico, G.E., Brown, L.A., White, L.K., Gur, R.C., & Gur, R.E. (2020). Resilience, COVID-19-related stress, anxiety and depression during the pandemic in a large population enriched for healthcare providers. *Transl. Psychiatry 10*.

Eroglu, A., Suzan, O.K., Hur, G., & Cinar, N. (2023). The relationship between fear of COVID-19 and psychological resilience according to personality traits of university students: A PATH analysis. *Arch. Psychiatr. Nurs. 42*, 1–8.

Gundogan, S. (2021). The mediator role of the fear of COVID-19 in the relationship between psychological resilience and life satisfaction. *Curr. Psychol.* 12, 6291–6299.

Kuldas, S., Hashim, S., Ismail, H.N., & Samsudin, M.A. (2015). The need for an academic resilience approach to cognitive task performance of Malaysian students in secondary schools and higher education. *Pertanika J. Soc. Sci. Humanit. 23,* 553–566.

Rudd, G., Meissel, K., & Meyer, F. (2021). Measuring academic resilience in quantitative research: A systematic review of the literature. *Educ. Res. Rev. 34*, 100402.

Rutter, M., 2012. Resilience as a dynamic concept. *Dev. Psychopathol. 24*, 335–344.

Trinidad, J.E. (2021). Teacher satisfaction and burnout during COVID-19: What organisational factors help? *Int. J. Leadersh. Educ.* 1–19.

Yamamoto, T., Nishinaka, H., & Matsumoto, Y. (2023). Relationship between resilience, anxiety, and social support resources among Japanese elementary school students. S*oc. Sci. Humanit. Open 7,* 100458.

Yang, M., Oh, Y., Lim, S., & Kim, T. (2023). Teaching with collective resilience during COVID-19: Korean teachers and collaborative professionalism. *Teach. Teach. Educ. 126,* 104051.

Transforming Education with Project-Based Learning (PBL): Student Engagement in Dashboard Development for HR Management

Emelia Akashah Patah Akhir*, Shuhaida Shuhidan, Nurul Aida Osman, Najihah Zafira Zailai
Universiti Teknologi PETRONAS, Malaysia
*emelia.akhir@utp.edu.my

Introduction

In the quickly changing world of education, project-based learning (PBL) is a powerful pedagogical approach that promotes deep understanding, critical thinking, and practical problem-solving skills (Blumenfeld et al., 1991). This paper thoroughly presents the case study of using PBL to develop an Employee Performance Management Dashboard in the Human Resource (HR) division.

This paper shows how PBL could be used as a tool that effectively links theory with practice, especially in project management, data analytics, and visualisation by having students participate in this extensive project (Thomas, 2000). Tasks such as designing and implementing a Microsoft Teams dashboard to facilitate teamwork and communication, creating Power BI for interactive data visualisation, and utilising Excel for data processing are included in the assignment. The process allowed full engagement throughout the project lifecycle, which adhered to agile methodology principles such as requirements gathering, design, development, testing, deployment, and review (Beck et al., 2001). Additionally, prior experience involves honing skills in project management collaboration, iterative troubleshooting, and technical proficiency improvement.

This case study presents compelling evidence for the potential of PBL to change education by emphasising intertwined knowledge integration, practical skills development, and active student engagement (Prince, 2004). It highlights how PBL prepares students for tackling real-world challenges, especially in disciplines that demand technological literacy and data-driven decision-making. The insights gained from this project underscore the critical importance of including PBL in the academic curriculum to make educational practices more responsive to the changing demands of business. Therefore, educational institutions can prepare their students well enough to compete effectively in future job markets, thus creating a workforce equipped with the necessary tools to navigate modern industries' complexities (Dabbagh & Kitsantas, 2012).

Several significant tasks were involved in the Employee Performance Management Dashboard project, illustrating how theories are applied practically. Students had to conduct a comprehensive needs analysis to understand HR division requirements, design a user-friendly interface for the dashboard in Power BI, and employ Excel for data processing and analysis. Ensuring the accuracy and reliability of dashboard information was a crucial component (Markham et al., 2003). Microsoft Teams facilitated seamless communication and collaboration among team members, enabling them to work cohesively toward achieving project objectives.

Throughout the project, students encountered challenges that necessitated critical thinking and problem-solving skills. They faced

data integration issues, visualisation design challenges, and user interface usability problems. By overcoming these obstacles, learners gained a deeper understanding of managing and analysing large datasets and the significance of user-centric designs for compelling data visualisations (Larmer & Mergendoller, 2010).

The application of the agile methodology played a crucial role in the project's success. Agile's iterative nature allowed students to continuously refine and improve their work based on feedback from stakeholders and peers (Beck et al., 2001). This approach enhanced the final product's quality and nurtured a culture of constant improvement among students. Regular sprint reviews and retrospectives provided moments for reflection and learning, leading to adjustments in subsequent iterations.

The practical skills acquired through this project extended beyond technical proficiency in data analytics and visualisation. Students also honed their project management skills, learning to prioritise tasks, manage time effectively, and coordinate with team members to meet deadlines (Jang, 2016). The collaborative nature of the project fostered strong teamwork and communication skills, which are essential for success in any professional setting (Boud & Solomon, 2001). Moreover, the experience of working on a real-world project provided students with valuable insights into the challenges and dynamics of workplace environments, better preparing them for future careers.

This case study demonstrates the transformative potential of PBL in education, particularly in fields that require a high level of technological competence and data literacy. By engaging students in meaningful, real-world projects, PBL bridges the gap between classroom learning and practical application, ensuring that students are well-equipped to meet the demands of modern industries (Krajcik & Shin, 2014). The Employee Performance Management Dashboard project exemplifies the effectiveness of PBL in fostering a holistic educational experience that integrates knowledge, skills, and active engagement.

The findings from this case study advocate for the widespread adoption of PBL in academic curricula, especially in disciplines such as project management, data analytics, and visualisation. Educational institutions must recognise the value of aligning their teaching methods with industry requirements to better prepare students for professional success. By incorporating PBL into their programs, institutions can cultivate a generation of graduates proficient in their technical fields and possess the critical thinking, problem-solving, and collaborative skills necessary to thrive in today's rapidly changing world (Thomas, 2000).

Acknowledgement

This paper is funded by the Collaborative Research Fund (CRF) 015ME0-393.

References

Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*(3-4), 369-398.

Thomas, J.W. (2000). *A review of research on project-based learning*. San Rafael, CA: Autodesk Foundation.

Larmer, J. & Mergendoller, J.R. (2010). Seven essentials for project-based learning. *Educational Leadership, 68*(1), 34-37.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223-231.

Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M. (2001). Manifesto for Agile Software Development. *Agile*. http://agilemanifesto.org.

Dabbagh, N. & Kitsantas, A. (2012). "Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning." *The Internet and Higher Education, 15*(1), 3-8.

Jang, H. (2016). Identifying 21st-century STEM competencies using workplace data. *Journal of Science Education and Technology, 25*(2), 284-301.

Markham, T., Larmer, J. & Ravitz, J. (2003). Project-based learning handbook: A guide to standards-focused project-based learning for middle and high school teachers. Novato, CA: Buck Institute for Education.

Boud, D. & Solomon, N. (2001). *Work-based learning: A new higher education?* New York: McGraw-Hill Education.

Krajcik, J.S. & Shin, N. (2014). Project-Based Learning. In R.K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (Second Edition, pp. 275-297). Cambridge University Press.

Catalysing Change: Transformative Teaching and Learning with Sustainable Business Innovations

Mohd Herry Bahador
Universiti Teknologi PETRONAS, Malaysia
*herry.bahador@utp.edu.my

Introduction

Transformational education is an innovative approach that connects academic learning with real-world applications. The title "Catalysing Change: Transformative Teaching and Learning with Sustainable Business Innovations" reflects efforts to transform teaching approaches through sustainable business innovations. Innovation in education, mainly through projects such as rechargeable solar batteries for electric scooters on campus, shows how the combination of transformation, learning, and sustainability is in nurturing responsible future leaders.

This approach increases student engagement and builds critical thinking skills and a deep understanding of sustainability practices. This project shows how students can actively plan and implement innovative solutions that support sustainable development. In this way, teaching transformation through sustainable business innovation not only benefits students but also has a positive impact on society and the environment. This approach can be the best example of how higher education can prepare graduates to face the challenges of an increasingly complex and changing world.

Literature Review

The transformational education approach has gained attention in academic circles because it links theory with practical practice (Table 1).

According to Levdansky and Izak (2017), transformational education emphasises student-centred learning and critical and creative skills development. This approach focuses on how students can actively participate in their learning process, leading to a deeper and more meaningful understanding.

Previous studies have shown that technology, such as rechargeable solar batteries, can enhance the learning experience through innovation (Jones & Smith, 2018). This was

Table 1 Previous studies on transformational education and sustainable innovation

Author	Study	Key Findings
Levdansky & Izak (2017)	Transformative education and student-centered learning	Emphasizes meaningful learning and the developmentof critical skills
Jones & Smith (2018)	Use of technology in education	Technology enhances learning experiences and innovation
Brown et al. (2019)	Hands-on projects and problem-solving	Encourages critical thinking and creativity among students

evident in the solar battery project for electric scooters, where students could apply their knowledge in an authentic context. According to Brown et al. (2019), projects like this encourage students to think critically and solve problems in a challenging but constructive atmosphere.

In addition, a study by Patel and Kumar (2020) states that project-based teaching can increase students' awareness of sustainability issues, which is in line with the Sustainable Development Goals (SDGs). The integration of sustainable business innovation in the higher education curriculum is seen as an effective way to prepare graduates to face future challenges.

Research Methodology

Study Design

This study collects data through tasks submitted by students in tutorial sessions, which are evaluated based on a predetermined rubric to identify students who demonstrate excellent innovation and critical thinking.

Evaluation and Selection

Students are assessed on their ability to:

1. Analysing trade performance and the impact of small and medium enterprises (SMEs) on the Malaysian economy.
2. Produce effective infographics and understand the content presented.

Short Listing

Students who get a high rating based on the rubric will be shortlisted to be involved in a new group. This group will combine ideas from the original project to form a perfected title.

Data Collection

The data collection process involves submitting materials required for the International Innovation ARSVOT Malaysia 2024 (IAM2024) competition, which is evaluated to determine their eligibility.

Assignment Submission

Students submit three types of materials as submission requirements:

1. Project Slides: Covers problem statement and justification. Between 5 and 10 slides.
2. Project Poster: A3-sized poster that covers the main components of the project.
3. Innovation Pitch (Video): A maximum 5-minute video that displays the innovation process.

Data Analysis

Data analysis aims to identify the characteristics of creativity, originality of ideas, and commercialisation potential of each submitted project.

Evaluation Criteria

Evaluation of projects based on rubrics, which include originality, relevance to theme, development techniques, diversity of innovation, and student understanding.

This methodology is arranged to ensure the selection of the most innovative and high-potential projects to be submitted to the IAM2024 Competition.

Result And Discussions

In the ARSVOT International Innovation Competition Malaysia 2024 (IAM2024), our group with ID IAM172 won the Silver Award for the project "Empowering Sustainable Mobility: Solar-Chargeable Batteries for E-Scooters on Campus", This is a proud achievement, especially when compared to a large number of entries, namely 243, involving various institutions.

This project is the fruit of efforts fostered in Project Learning (PBL): Business Idea Generation (CLO3: Interpret the main challenges modern business faces, PLO3: Communicate ideas effectively), where we emphasise practical business innovation and sustainability. This assignment requires students to interpret the main challenges faced by modern businesses and communicate their ideas effectively, focusing on sustainability and compatibility with SDGs 9 and 12.

Emphasis on Sustainability

The achievement of the Silver Award underscores how integrating education, sustainability, and innovation can interact to produce high-impact results. This is not only a reflection of the student's technical abilities but also their ability to convey and defend ideas based on the principle of sustainability. This success reflects the learning applied through the analysis of the business model canvas and the detailed focus on eco-friendly practices discussed in the project.

Competition Statistics

The competition at IAM2024 was intense, with 26 gold awards, 46 silver awards, and seven bronze awards given out. Our success in this category signifies recognition of the quality and relevance of our projects in a broader context since the participating students are in the first semester of their study at the foundation level.

Implications for Education and Innovation

This success marks current achievements and paves the way for further development in sustainability and technology. It also reinforces the importance of education, which integrates theory with practical application to build responsible and innovative future leaders. The certificate of achievement for the silver award is in Figure 1.



Figure 1 Certificate of Achievement Silver Award IAM2024

Conclusion

The success of winning the silver award in IAM2024 is a proud achievement and proves the effectiveness of project-based learning in developing innovation and sustainability skills among students. It emphasises the importance of integrating global issues such as environmental sustainability into the higher education curriculum, allowing students to apply theories in real contexts that impact society and industry.

This project shows how knowledge can be transformed into action that solves real problems, encouraging us to continue to find more effective and sustainable solutions while preparing students to be responsible future leaders.

Acknowledgement

The authors would like to thank the Dean's Office, Center for Foundation Studies, Universiti Teknologi PETRONAS, for support in IAM2024. Not to forget, thanks to the Project Leader, Adi Ahmad Danish bin Adi Nor, as well as group members Ainin Sofieya binti Ahmad Shafie, Aleesya Azhariyah binti Azhar, Rynna Qarmila binti Ruslan, and Muhammad Fahmi bin Mohd Dip for their dedication and teamwork.

References

Brown, C., Davis, D., & Evans, E. (2019). *Project-based learning and sustainability in higher education*. *Sustainability and Education Journal*, *15*(4), 215-230.

Jones, A., & Smith, B. (2018). *The role of technology in modern education*. *International Journal of Technology in Education*, *9*(2), 102-115.

Levdansky, E., & Izak, M. (2017). *Innovative approaches in transformative education*. *Journal of Educational Innovation*, *12*(3), 45-58.

Patel, R., & Kumar, S. (2020). *The impact of SMEs on economic growth in Malaysia*. *Asian Economic Review*, *22*(1), 30-45.

Enhancing English Communication Skills for Japanese Gen Z University Students through AI-Integrated Cross-Cultural Learning Module

Nurhasmiza Sazalli*, Nuraqilah Nadjwa Miskam, Izyanie Khazali
Universiti Teknologi Malaysia, Malaysia
*nurhasmiza.kl@utm.my

Introduction

Effective communication in English has become a vital skill in a globalised world, especially for university students preparing to enter international job markets. Generation Z (Gen Z) individuals born between the mid-1990s and early 2010s have grown up with digital technologies and social media, making their learning preferences and behaviours distinct from previous generations. In this context, traditional methods of teaching English communication fail to meet the needs of Gen Z students, particularly those in non-English-speaking countries like Japan. There is a growing need to integrate technology and interactive, real-world activities into language learning modules focusing on linguistic competence, cultural understanding, and practical application. This research investigates the effect of using an Artificial Intelligence (AI) Integrated Cross-Cultural Learning Module to enhance English communication skills among Japanese Gen Z university students. The module integrates an AI tool called Yoodli and interactive activities, including cooking demonstrations, product reviews, and cross-cultural comparisons between Japan and Malaysia. Additionally, the module incorporates excursions to significant landmarks in Malaysia to enhance students' English communication skills. The primary aim of this study is to create an engaging, interactive, and culturally enriched learning environment that promotes both English communication skills and students' cultural awareness.

Literature review

The increasing globalisation of markets and industries has necessitated the development of strong English communication skills, particularly in non-English-speaking countries like Japan. English proficiency is essential for academic success, career advancement, and cross-cultural communication (Butler & Lino, 2005; Xia et al., 2024). However, traditional language learning methods in Japan have often focused on grammar and reading, with limited emphasis on practical communication skills (Ohta, 2001). It has created a gap between linguistic knowledge and actual language use in real-world settings, a challenge further compounded by cultural and social differences in communication styles (Miller, 2000; Ochieng & Price, 2010).

Gen Z Learning Preferences and Technology Integration

Generation Z, born between the mid-1990s and early 2010s, presents unique challenges and opportunities for language education. As digital natives, they have grown up with the internet,

smartphones, and social media to shape their learning preferences. A study by Henny and Khairun (2024) highlighted that Gen Z learners expect learning environments to be interactive, engaging, and supported by technology. These students thrive in environments that provide instant feedback, personalised learning pathways, and practical, real-world applications of knowledge (Schwieger & Ladwig, 2018). Therefore, integrating technology, especially AI, into language learning has become increasingly important. Studies show that AI tools substantially enhance language learning by providing personalised, real-time feedback on pronunciation, grammar, and fluency (Burston, 2015). Studies have demonstrated that AI can adapt to individual learners' needs, offering tailored exercises and assessments to improve weak areas and making the learning process more efficient (Heil et al., 2016). Moreover, AI-based language learning apps like Duolingo and Rosetta Stone have shown that incorporating gamification elements—such as points, rewards, and levels—can increase motivation and engagement, which is particularly important for Gen Z students (Loewen et al., 2019).

Interactive and Culturally Immersive Learning

Interactive learning, where students actively participate in tasks that mimic real-world scenarios, has proven to be an effective strategy for developing communication skills. Brown (2007) suggested that language learners benefit more from practical, situational contexts where they can practice speaking and listening skills rather than just theoretical instruction. In the context of this research, activities such as cooking demonstrations, product reviews, and excursions provide authentic communication experiences, allowing students to apply their English skills in meaningful, real-life situations. Cultural immersion is another key factor in language acquisition. Lightbown and Spada (2013) stressed the importance of language input, interaction, and practice in realistic contexts. They argue that learners benefit from exposure to language in meaningful situations where they can practice listening and speaking. Learners' Kramsch (1993) argues that learners use a language more effectively when they understand the cultural context in which it is spoken. In this research, cross-cultural comparisons, such as those between Japan and Malaysia, promote cultural awareness and sensitivity, which are critical components of effective communication. Studies have shown that cultural immersion improves students' language fluency, intercultural competence, and empathy, helping them navigate diverse social and professional environments (Byram, 1997).

Challenges in Japanese English Education

Despite efforts to reform English education in Japan, such as the 2003 "Action Plan", which aimed to improve communicative competence (Butler & Lino, 2005), many Japanese students still face challenges in acquiring functional English skills. Cook (2009) argues that this is mainly due to overemphasising rote memorisation and examination-focused learning, which leaves students unprepared for real-life conversations. Moreover, Japanese communication styles, typically more indirect and formal than Western styles, can further complicate the acquisition of conversational English (Miller, 2000). Incorporating cross-cultural activities into language learning can bridge these gaps. By exposing Japanese students to Malaysians' more direct and informal communication style through cultural exchanges, this research seeks to promote a deeper understanding of how communication varies across cultures. It helps students develop a more adaptable communication style essential for global success (Hofstede, 2011).

Cross-Cultural Learning and Excursions

Cross-cultural learning has been recognised as a powerful tool for developing both language skills and cultural competence (Byram, 1997). Excursions, such as those incorporated in

this module to key landmarks in Malaysia, allow students to practice English in real-world, culturally rich environments. These excursions encourage students to use language in diverse contexts, reinforcing their linguistic and cultural learning. Furthermore, comparing cultures, such as Japanese and Malaysian customs, traditions, and social norms, helps students appreciate cultural diversity and recognise the importance of cultural sensitivity in communication. Hofstede's (2011) research on cultural dimensions underscores the value of understanding cultural differences in global interactions. In this context, the excursions and cultural activities provide students firsthand experience navigating these differences, enhancing their language and cultural competence. In addition, Jackson (2019) explored how international education, such as study abroad programs and educational excursions, will improve intercultural competence. Her work supported the idea that cultural immersion through excursions allows language learners to engage directly with Hofstede's cultural dimensions, helping them develop sensitivity to cultural differences in global interactions.

Research Objectives

1. To explore the students' perception of using an AI-Integrated Cross-Cultural Learning Module to improve their English communication skills.
2. To explore the instructors' perception of using an AI-Integrated Cross-Cultural Learning Module to teach English communication skills.
3. To investigate how AI tools like Yoodli enhance students' English communication skills and confidence in English speaking.

Research Methodology

This study employed a qualitative research design to examine how an AI-integrated cross-cultural learning module improves the English communication skills of Japanese Gen Z university students. The participants were 24 university students from Japan attending a summer school program in Malaysia and three instructors who are experts in English language teaching and AI tools. Data is collected through student and instructor reflections, an observation checklist, and an oral presentation assessment rubric. These tools help gather insights into the module's effectiveness in enhancing communication skills.

The reflections were gathered from students and instructors to gain insights into their experiences and challenges using the module. The observation checklist was utilised to track the students' engagement with the activities, interaction with peers, and real-time use of AI tools. At the end of the module, students' oral presentations were evaluated using a rubric that measures fluency, content and organisation, pronunciation and intonation, and language. The data is analysed through content analysis to find key themes and patterns from the reflections. At the same time, descriptive statistics summarise the presentation scores to evaluate the module's effectiveness.

Result and Discussions

Based on the findings, the participants felt more confident and less nervous when speaking English in class because of the real-time feedback from Yoodli, an AI tool that helps improve English communication skills. They felt that learning adjectives expanded their vocabulary, which they effectively used in product reviews and final presentations. Although the role-play activities were challenging due to the need to think quickly and respond naturally in English, students saw them as valuable opportunities to step out of their comfort zones. This experience boosted their confidence and fluency and enhanced their ability to communicate in real-world situations.

From the instructors' perspective, while the role-plays encouraged active participation,

some students hesitated initially, indicating the need for more precise guidance and examples to build confidence. The AI tool, Yoodli, was appreciated for helping students reduce filler words. However, some students needed more support to understand the detailed feedback fully. It highlights the importance of blending AI tools with human guidance to maximise learning outcomes.

In addition to the participants' and instructors' reflections, data was also gathered through an observation checklist. The instructors observed that 90% of the students actively participated in the role-plays, but 25% hesitated to start conversations. This suggests that some students may need more support to feel confident. In the product review exercises, 70% of students used at least three target adjectives correctly, while others needed a little help. Peer interaction was good, with 80% of students engaging in discussions and giving helpful feedback. However, 20% were mostly passive listeners, which shows that more guidance might be needed to get everyone involved.

The presentation and speaking task assessments showed good progress. For fluency, the average score was 4 out of 5. Most students spoke smoothly, with only a few pauses. In pronunciation and intonation, the average was 3.5 out of 5, as some students had trouble with word stress, making their speech less clear. Content and organisation were rated high at 4.5 out of 5, as students organised their presentations well, with clear introductions, main points, and conclusions. For language, the average score was 3 out of 5. Although students used creative vocabulary, grammatical mistakes affected their overall communication.

The findings indicate that integrating AI tools and interactive activities in the module significantly improves students' communication skills, particularly regarding fluency, pronunciation, and confidence in speaking English. The personalised feedback provided by AI tools allows students to target specific areas for improvement, while the interactive activities offer opportunities for real-world language practice in culturally diverse settings. The cross-cultural component, particularly the comparisons between Japanese and Malaysian cultures, helps students become more aware of the role of culture in communication, leading to more culturally sensitive interactions. The results indicate that combining AI tools with human guidance offers a valuable approach to improving confidence and communication skills. However, further grammatical accuracy and pronunciation support is needed to ensure a more balanced skill development.

Conclusion

This study highlights the importance of integrating AI technology and culturally immersive activities into English language learning modules for Gen Z students. By addressing the unique learning preferences of Japanese university students, the module creates a dynamic, personalised, and interactive environment that promotes linguistic proficiency. The findings suggest that a cross-cultural, AI-enhanced module can significantly enhance communication skills, making it a valuable model for future language education programs in non-English-speaking countries.

References

Brown, H. D. (2007). *Principles of Language Learning and Teaching*, Fifth Edition, New York: Pearson Longman.

Burston, J. (2003). The Role of Instructional Technology in Foreign Language Teaching. *IALLT Journal of Language Learning Technologies, 35*(2), 17–30.

Butler, Y. G., & Lino, M. (2005). Current Japanese reforms in English language education: The 2003 "action plan". *Language Policy, 4*(1), 25-45.

Byram, M. (1997). *Teaching and Assessing Intercultural Communicative Competence*. Bristol: Multilingual Matters (Series).

Cook, H. M. (2009). *Socializing Identities through Speech Style: Learners of Japanese as A Foreign Language*. Bristol: Multilingual Matters.

Heil, C., Wu, J., Lee, J., & Schmidt, T. (2016). A review of mobile language learning applications: Trends, challenges, and opportunities. *The EuroCALL Review, 24*(2), 32-50.

Henny M., & Khairun N. (2024). Generation Z Students' perspectives on artificial intelligence (AI) technology in English Language Learning. *Journal of Literature, Linguistics, and Language Teaching, 5*(1), 1-11.

Hofstede, G. (2011). *Culture's consequences: Comparing values, behaviors, institutions and organizations across nations*. Los Angeles: Sage.

Jackson, J. (2019). *Interculturality in International Education*. Oxfordshire: Routledge.

Kramsch, C. (1993). *Context and Culture in Language Teaching*. Oxford: Oxford University Press.

Lightbown, P. M., & Spada, N. (2013). *How languages are learned*. Fourth Edition, Oxford: Oxford University Press.

Loewen, S., Isbell, D. R., Sporn, Z., & MacFadyen, S. (2019). Mobile-assisted language learning: A Duolingo case study. *ReCALL, 31*(3), 293-311.

Miller, L. (2000). Negative assessments in Japanese-American workplace interaction. *Journal of Pragmatics, 32*(5), 543-566.

Ochieng, E.G. & Price, A.D. (2010). Managing cross-cultural communication in multicultural construction project teams: The case of Kenya and UK. *International Journal Project Management, 28*, 449–460.

Ohta, A. S. (2001). *Second Language Acquisition Processes in The Classroom: Learning Japanese*. Oxfordshire: Routledge.

Schwieger, D., & Ladwig, C. (2018). Reaching and retaining the next generation: Adapting to the expectations of Gen Z in the classroom. *Information Systems Education Journal, 16*(3), 45-54.

Xia, Y., Shin, S.Y., & Kim, J.C. (2024), Cross-Cultural Intelligent Language Learning System (CILS): Leveraging AI to facilitate language learning strategies in cross-cultural communication. *Applied Sciences, 14*(13, 5651.

Monitoring Student Progress through Continuous Online Questionnaires of the Learning Materials

Mohd Hilmi Noh*
Universiti Teknologi PETRONAS, Malaysia
*hilmi.noh@utp.edu.my

Introduction

In today's higher education era, success is usually defined by the marks or grades achieved by every student. To achieve this goal, educators need tools to help them identify students who are at risk academically and adjust instructional strategies to meet these students' needs better (Deno et. al., 2003). Student progress monitoring is a practice that allows educators to utilise student performance data to evaluate their teaching constantly and provide a more informed instructional decision. Student progress monitoring is different if compared to mastery measurement approaches. Mastery measurement indicates whether the student has learned the lesson contents covered but not whether the student is learning at a rate that will enable them to accomplish yearly learning objectives (Safer et. al., 2005)

Educators need to regularly assess students' current understanding of the lessons they have learned to implement student progress monitoring. This allows educators to determine the rate of progress and understanding the student has achieved to conduct the required administered learning intervention (Fuchs et. al., 2001).

Progress Monitoring Through Online Questionnaires

The outlines below explain the progress monitoring through online questionnaires, such as the following:

1. Conventional summative assessments (e.g., quizzes, tests, projects, etc.) measure students' mastery of the course but not their current learning progress (Safer et al., 2005).
2. Educators need to regularly determine students' current progress level throughout the semester so that early administered intervention can be conducted (Deno et. al., 2003).
3. Frequent online questionnaires could be one of the solutions for regular students' progress monitoring.
4. These frequent online questionnaires should be straightforward to assess students' understanding of all topics covered in a course.
5. Analysis of these questionnaires can help educators pinpoint struggling students precisely so that early intervention can be effective.

The Questionnaires

The questionnaires should be simple and straightforward. The questionnaires can be conducted physically or online. However, the latter will help educators analyse more quickly as the online platform will tabulate everything. For example, ULearn or other MOOC platforms have this function.

The most uncomplicated questionnaire that can be made is something like a multiple-choice question set. Each set should contain at least 10

questions related to the topic covered. There are multiple types of MCQs, such as single-select MCQ, multi-select MCQ, drag and drop MCQ, rank order MCQ, and many others. All these types of MCQs are usually available inside ULearn. A good set of online questionnaires should include multiple types of these MCQs to have some variation on how the students need to test their understanding.

Using MOOC platforms like ULearn, educators can easily create these MCQ question banks, which can be reused infinitely.

The Analysis

By extracting all the data from the MOOC platform, the analysis could be done for each set of questionnaires. Usually, the data collected by the system is correct/incorrect responses, time spent answering the questionnaires, and start and finish times. With this information, educators can monitor student progress.

All the aforementioned information was tabulated in an Excel file. Using all the functions available in Excel, educators can do simple analyses accordingly and create some graphical representation to help pinpoint the struggling students. Info, such as the mean marks for each set of questionnaires, can significantly impact if used correctly.

Result and Discussion

Students' progress monitoring through online questionnaires has been conducted for Chemical Engineering Fluid Mechanics during the May 2024 semester. There were 45 students registered for the course, all from the same cohort.

Eleven sets of online questionnaires covering diverse topics in the course have been conducted throughout the semester. The questionnaires were conducted through ULearn and consisted of multi-select MCQs. Some questions involved calculation. Students were given a time limit of 15 to 20 minutes, depending on the topic covered, to complete the online questionnaires. Figure 1 depicts the result analysis for all sets of online questionnaires conducted for students who scored A and C+ for their coursework marks at the end of the semester.

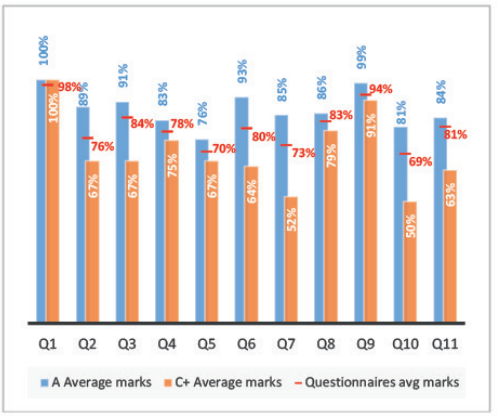


Figure 1 Average marks for A students, C+ students, and online questionnaires average marks

As shown in Figure 1, the average marks for all A students were consistently higher than the average marks for each questionnaire. On the other hand, C+ students scored lower than the average marks for all the questionnaires. With this result, we can conclude that students who manage to get below the average mark should be supervised for a possible learning intervention when each questionnaire has been conducted.

This means that either they have problems understanding the content of the topics (which also can be linked to how the educator runs the class) or they lack attention during class time. With proper intervention done in advance, these students could improve their understanding of the topic and might also score any other assessments for the course in general.

Intervention can be made as soon as the first questionnaire analysis is ready. Educators can take the initiative to improve the class's conduct for the rest of the following questionnaires.

Conclusion

The method of continuous online questionnaires for every learning session managed to monitor the understanding of the students. With this method, early intervention can be conducted without delay to ensure no student is left behind. The semester is relatively short, especially in UTP; hence, this method could avoid any failures in any subject.

Acknowledgement

The teaching methods presented in this publication result from learning and sharing by the CADEX team in UTP. The author thanks them for their active engagement.

References

Safer, N., & Fleischman, S. (2005). Research matters: How student progress monitoring improves instruction, *Educational Leadership*, *62*(5), 81-83.

Deno, S. L. (2003). Developments in curriculum-based measurement, *The Journal of Special Education, 37*(3), 184-192.

Fuchs, L. S., & Fuchs, D. (2001). *What is scientifically-based research on progress monitoring? (Technical report)*. Nashville, TN: Vanderbilt University.

Augmented Reality: A New Frontier in Learning Computer Internal Systems

Saipunidzam Mahamad*, Suziah Sulaiman, Ahmad Nuris, Iqmal Faizul, Chin Yi Han
Universiti Teknologi PETRONAS, Malaysia
*saipunidzam_mahamad@utp.edu.my

Introduction

Technological advancements have transformed education, particularly in computer science, where traditional methods like textbooks and lectures often struggle to engage students or explain complex concepts effectively. These static tools can lead to disengagement and outdated learning in fast-evolving fields like Science, Technology, Engineering, and Mathematics (STEM). Augmented Reality (AR) offers a promising solution by merging digital content with the real world, creating immersive, interactive learning experiences. Studies show educators increasingly recognise technology's potential in the classroom. Microsoft research found that 87% of educators expect more technology use post-pandemic (Ganeswaran, 2020), while an EdWeek survey revealed 73% believe better access to computers will improve teaching quality, supporting AR's role in enhancing education (Bushweller, 2022).

This paper explores AR's potential to enhance students' learning experiences by studying internal computer systems. We will develop and evaluate an AR application tailored for this purpose, assessing its impact on engagement, comprehension, and knowledge retention. This study will provide insights into AR's integration into technical education and its broader implications for enhancing learning by incorporating surveys, assessments, and user feedback.

Literature Review

Enhancing learning involves improving the educational process's quality and efficiency, fostering cognitive growth, critical thinking, and problem-solving skills. Technology, when used strategically, can significantly enhance traditional teaching methods. AR, for instance, has gained widespread use in various sectors, including education, for its ability to visualise complex concepts more effectively (Arena et al., 2022). AR technology allows students to view intricate structures, such as the human body, molecular formations, or solar system models, in three dimensions, enhancing their understanding of these topics (Jo & Kim, 2019).

Studies underscore AR's effectiveness in improving learning outcomes. For example, Ibáñez and Delgado-Kloos (2019) found that AR-based learning environments significantly improved students' comprehension of complex computer science topics. Similarly, Akçayır et al. (2021) demonstrated that AR applications significantly improved academic performance and information retention in computer hardware education. The interactive nature of AR allows students to visualise and manipulate 3D models of computer components, deepening their understanding of how these components function and interconnect.

Methodology

This study involves developing, implementing, and evaluating an AR application called ComputAR to enhance learning about computer internal systems. The application provides interactive 3D models of key components, such as the CPU, RAM, motherboard, and storage devices. The architecture of ComputAR centres on a user-centric approach, with a user interface (UI) serving as the central hub for navigating its functionalities. The UI connects to the App Logic and Rendering Engine, which interprets user interactions and retrieves data from the database. The database stores learning content, 3D models, exercise questions, and user data.

The Vuforia Engine, a component of ComputAR, specialises in image recognition. It analyses the camera feed to detect specific images in the user's environment and overlays a virtual 3D model onto the real world. This system allows users to engage with AR experiences seamlessly. ComputAR's architecture aims to deliver educational content that makes learning about computer hardware more interactive and engaging.

Results and Discussion

A preliminary survey was conducted among students and teachers who have experience learning or teaching internal computer systems. The survey, which used a five-point Likert scale, gathered responses from around 30 participants. The feedback revealed that while many were satisfied with traditional teaching methods, they also recognised the potential of digital tools like AR to enhance learning experiences.

As illustrated in Figure 1, the survey showed that over 40% of respondents were neutral regarding the difficulties of learning materials, while 30% agreed that they faced challenges. About 50% of respondents were satisfied with the current lectures on computer components, but 17% expressed difficulties understanding the material. Furthermore, 93% of participants agreed that AR applications could enhance their understanding of computer systems, and 90% supported the development of an AR application specifically for computer component lectures. These results highlight the need for additional resources to aid learning, with AR technology offering a promising solution to improve engagement and comprehension.

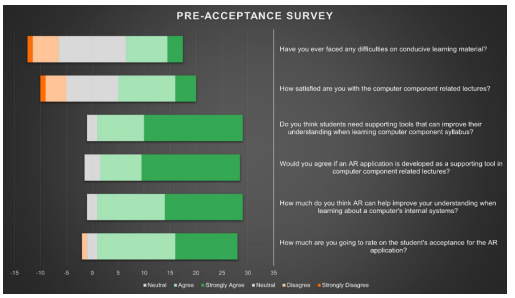


Figure 1 Pre-acceptance survey



Figure 2 The ComputAR application

ComputAR's design, as shown in Figure 2, prioritises user-centricity, ensuring that the interface is intuitive and accessible for learners of all backgrounds. Its true innovation lies in AR's ability to enable students to interact with 3D models of computer components in real-world settings. For instance, students can hold a virtual CPU or visualise the connections between elements on a motherboard, fostering a more engaging and immersive learning experience. However, AR's integration in education is not without challenges. The technical complexity and cost of developing and implementing AR applications can be significant barriers to widespread adoption. Additionally, cognitive overload is a concern, as AR environments can sometimes overwhelm students with too much information at once. Careful design is needed to balance AR's immersive elements with traditional teaching methods.

Conclusion

ComputAR represents a significant step forward in enhancing computer systems education through AR. The application has demonstrated the potential to improve student engagement, comprehension, and retention by incorporating interactive learning modules and exercises. The pre-acceptance survey showed strong interest from students and educators, confirming the demand for AR-based tools in technical education. ComputAR could become a powerful educational tool with further development and refinement, transforming how computer systems are taught and learned. The application has the potential to bridge the gap between theoretical knowledge and practical understanding, paving the way for more immersive and dynamic learning experiences in STEM education.

References

Akçayır, M., Akçayır, G., & Karahan, E. (2021). A meta-Analysis of Augmented Reality Applications in STEM Education. *Educational Technology Research and Development, 69*(5), 2301-2332.

Arena, F., Collotta, M., Pau, G., & Termine, F. (2022). An Overview of Augmented Reality. *Computers, 11*(2), Article 28. https://doi.org/10.3390/computers11020028

Bushweller, K. (2022, January 27). *How COVID-19 is Shaping Tech Use. What That Means When Schools Reopen*. Education Week. https://www.edweek.org/technology/how-covid-19-is-shaping-tech-use-what-that-means-when-schools-reopen/2020/06

Ibáñez, M. B., & Delgado-Kloos, C. (2020). Augmented Reality for STEM learning: A systematic review. *Computers & Education, 144*, 103654.

Jo, D., & Kim, G. J. (2019). AR Enabled IoT for a Smart and Interactive Environment: A Survey and Future Directions. *Sensors (Basel), 19*(19), Article 4330. Doi:10.3390/s19194330

Ganeswaran, D. (2020, July 23). Microsoft. Leading the future of education with technology. *Microsoft*. https://news.microsoft.com/en-my/2020/07/23/microsoft-leading-the-future-of-education-with-technology/

Implementation of Blended Learning Method in the Separation Process

Khairiraihanna Johari[*1], Chuah Chong Yang[2], Abdul Rahman Abdul Rahim[1]
[1] Department of Chemical Engineering, Universiti Teknologi PETRONAS, Malaysia.
[2] Department of Chemical Engineering, Faculty of Engineering, Universiti Malaya, Malaysia
[*]khairiraihana.j@utp.edu.my

Introduction

The COVID-19 pandemic disrupted education worldwide, forcing many countries to transition from conventional teaching and learning (T&L) to online learning. While online learning platforms such as LinkedIn learning, edX, Udemy, and Coursera (Virani et al., 2023) offer flexibility and accessibility, they also have limitations. Learners must be self-motivated and persistent, as their progress will not be monitored as closely as in formal learning. Additionally, online learning lacks the personalised support that conventional classrooms provide. Several approaches have been widely used to address these challenges and fulfil engineering programs offered by academic institutions. These institutions must adhere to the regulations set by the Engineering Accreditation Council (EAC) under the Board of Engineers Malaysia (BEM) to ensure the accreditation of their courses.

One approach to address these challenges is to implement a blended learning method. Blended learning combines online and face-to-face instruction, providing a more personalised and practical learning experience. By incorporating elements of both online and traditional learning, blended learning can help to bridge the gap between the two approaches and provide students with the best of both worlds. For example, blended learning can deliver lectures online, allowing students to access them conveniently and conveniently. Face-to-face sessions can be used for more interactive activities like group work, problem-solving, and feedback. This approach can help improve student engagement and motivation and give students the support they need to succeed. Hence, investing in these areas can help ensure all students have access to quality education, regardless of their circumstances.

Related Work/Literature Review

Universiti Teknologi PETRONAS (UTP) is classified as the Institution of Higher Learning (IHL), has set a target by 2025 to ensure that at least 60% of the courses to be developed under this new format ensure that the university abides by the recent guideline that the MOHE Malaysia imposes. Under this plan, UTP has instructed the lecturers to start with the implementation of blended learning in the May 2022 semester.

Blended learning generally involves integrating conventional face-to-face and technology-mediated approaches for the instructor to deliver the content to the studen
“““““ts (Ministry of Education Malaysia, 2013; Muhria et al., 2023; Wu et al., 2024). This learning method will allow the students to learn at their own pace and time, considering that different learning styles are present across each student. Thus, based on the typical 12-week session offered in UTP, this method will be prepared through both asynchronous and

synchronous (i.e., live) sessions under 30% and 70%, respectively. Therefore, a minimum of three weeks will be offered asynchronously. Thus, in this study, this paper will focus on the preparation, implementation, and challenges encountered during the blended learning approach. Lastly, improvement plans for these subjects will be proposed to ensure this learning approach can be effectively implemented in subsequent semesters across different subjects.

Research Methodology

The course planning and design for implementing blended learning are elaborated below based on the Separation Process (January 2023 and January 2024).

Planning and Design for Separation Process (January 2023 and 2024)

The separation process is a required component in Chemical Engineering to equip students with the fundamentals of the separation process principle. The scope of this subject will involve the design of processes such as adsorption, evaporation, drying, crystallisation, ion exchange, and membranes. At the end of the course, students are expected to solve the separation process involving gas-gas, liquid-liquid, and solid-solid systems using an energy balance. Based on the course planning in Figure 1, weeks 3, 5, and 11 have been selected for the blended learning session. The exact schedule was adopted in January 2023 and 2024, mainly considering the holiday celebrations (Chinese

Timetable

Week 1	Week 2	Week 3	Week 4		Week 5		Week 7	Week 8	Week 9	Week 10		Week 11		Week 12
Lecture (Intro)	Lecture (Ads)	Lecture (IE)	Lecture (IE)	Lecture (Cryst)	Lecture (Cryst)	Lecture (Cryst)	Lecture (Memb)	Lecture (Memb)	Lecture (Dry)	Lecture (Dry)	Lecture (Evap)	Lecture (Evap)	Sub IDP	Lecture (Evap)
Lecture (Ads)	Lecture (Ads)	Lecture (IE)	**Test 1**		Lecture (Cryst)		Lecture (Memb)	Lecture (Memb)	Lecture (Dry)	**Test 2**		Lecture (Evap)		Lecture (Evap)

Figure 1 Class planning for process heat transfer. The orange shading indicated in the figure depicts the session where the blended learning session will be conducted

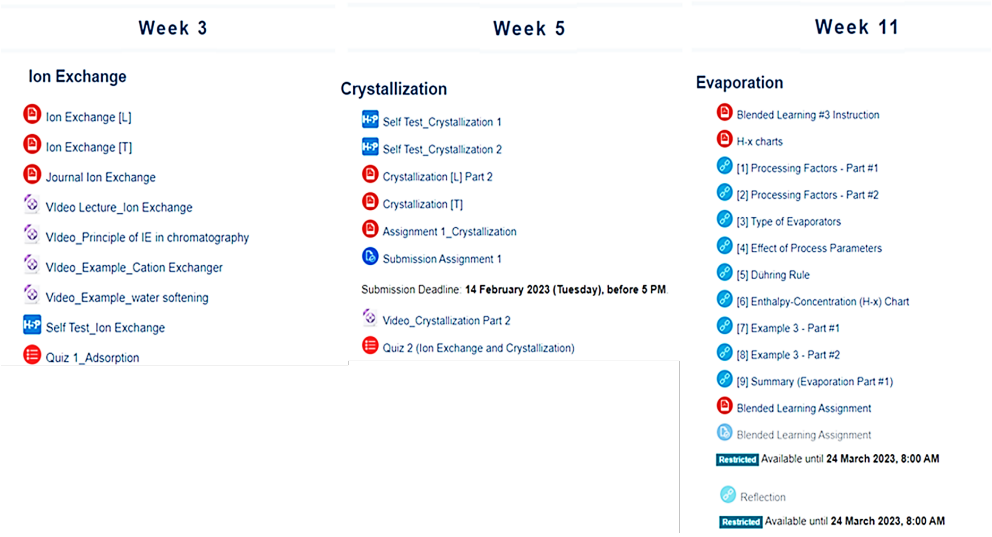


Figure 2 Implementation of blended learning content on Weeks 3, 5 and 11

New Year (CNY) and Thaipusam) that fall on these specific weeks. In the next step, the blended learning activities' student learning time (SLT) will be planned to ensure the student load is not overloaded with the learning materials. The required number of hours for SLT for a three-week duration is 36 hours. Therefore, a detailed lesson plan will be created for the selected weeks.

Once the class planning and learning activities have been arranged, the blended learning content will be provided in Weeks 3, 5, and 11 on the learning platform (i.e., Ulearn from Moodle platform), as indicated in Figure 2. Similarly, the contents are appropriately arranged to ease the students' accessibility to the provided learning materials.

Result and Discussions

Pre-questionnaire

First, to receive some expectations so that the students (sample size of 133 students) are aware and prepared for the courses where the blended learning format will be introduced to this subject, pre-questionnaires have been prepared to gather the responses. The questions for each section are summarised in Table 1. Hence, as indicated in Figure 3, the responses are summarised. It can be concluded that 96% of the students have encountered the term "blended learning" throughout their studies at UTP. Based on the preferred learning method, it was observed that 73% of the students in this cohort preferred to adopt blended learning as the learning format for this subject.. However, a substantial percentage of 22% of the students preferred the lecturers to deliver the lesson in an entirely physical setting. This result is expected to show its promise as it is consistent with the target set by the MOHE and UTP as elaborated in the introduction.

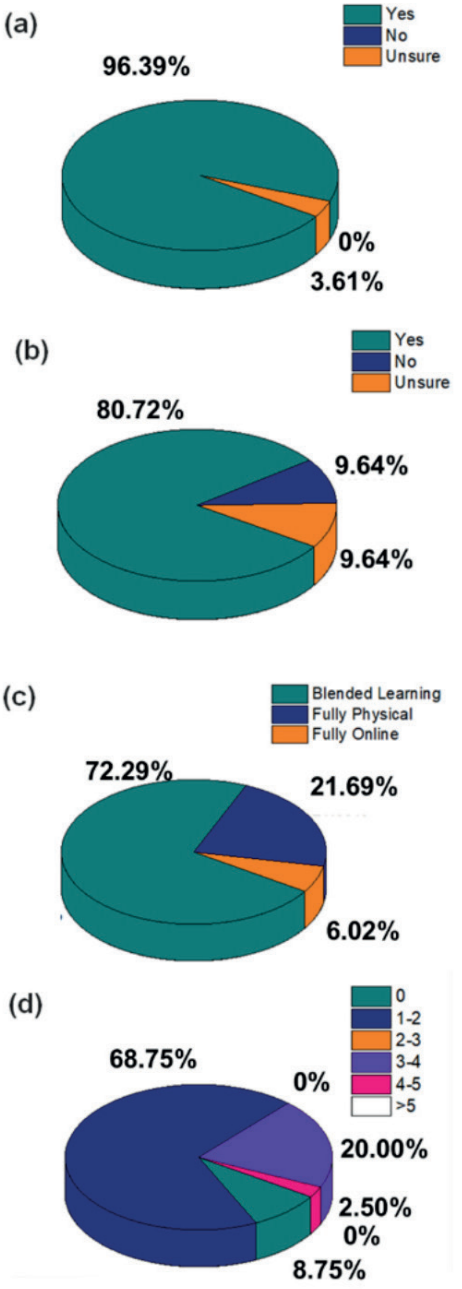


Figure 3 Summary of the result based on the expectation of the blended learning session for students attending the Separation Process

Table 1 Pre-questionnaire of the blended learning session

No.	Questions
1	Have you heard about blended learning throughout your studies at UTP?
2	For your information, this course has been selected to be delivered under a blended learning format. Therefore, you are expected to perform your self-paced learning for three weeks with potential graded assignments/quizzes. Please advise if you are aware of this.
3	What type of learning method do you prefer during your study at UTP?
4	How often (times per week) will you refer to the recorded videos after each lecture/tutorial session?

Access to Learning Activities and Assessments

Figure 4 shows the percentage of students that have access to the lecture recording, where, based on the summarised data, 56%, 45%, and 21% of the students have access to the recorded lectures. It can be observed that the results for weeks 3 and 5 are relatively comparable, with the exception of Week 11. Based on the feedback that the lecturers received from the students, the poor participation rate on that specific week was attributed to other assessments and tests from other courses the students have taken for this semester. Hence, with this consideration in mind, an additional live discussion session was arranged on that specific week to recap the contents covered in that particular week. With the presence of live discussion, an improvement of 41.4% in the total participation from students was observed. The live discussion will also be utilised to discuss the solutions for the assessments provided by the lecturers during the week of blended learning.

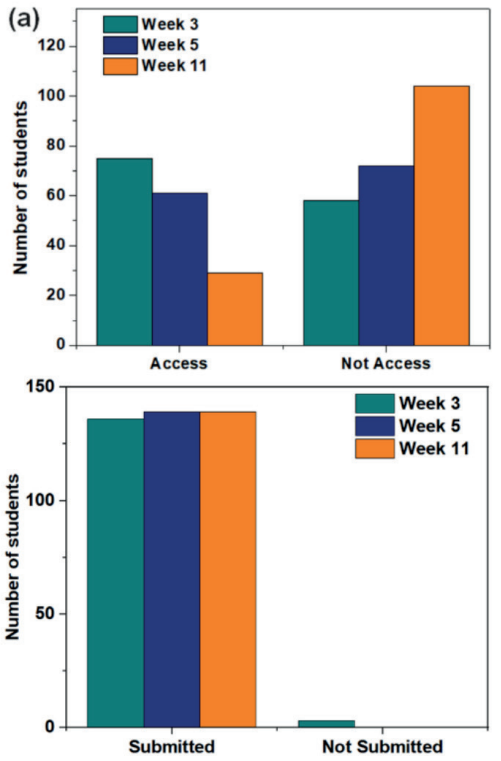


Figure 4 Number of students who have (a) accessed the lecture recording, (b) submitted to the assessments provided by the lecturers

Subsequently, based on the data in Figure 4, more than 80% of the students have submitted the assessment for the blended learning session. When blended learning was introduced in the Separation Process, all of the assessments prepared for this section were graded, and it was included as a part of the coursework completion. Based on the student performance, 30 to 40% of the total students in this specific cohort have obtained at least 80% (i.e., "A-" grade) and above, indicating that the students can grasp the content covered in the blended learning assignment.

Conclusion

Based on the findings, some challenges can still be observed while implementing blended learning for specific subjects. Although blended learning aims to train the students to learn the subject independently, it is still required for the students to be self-motivated. First, a recap session must be conducted after the week of blended learning sessions to recap the contents covered in the class. Second, a link must be provided for the students to raise their questions, and the information gathered will be clarified in the upcoming class. Nevertheless, based on the pre-questionnaire collected by the students, the acceptance of the blended learning approach has been positive.

Acknowledgement

The authors would like to acknowledge the financial support from Universiti Teknologi PETRONAS under the YUTP-FRG Grant.

References

Ministry of Education Malaysia. (2013). *Malaysia Education Blueprint 2013 - 2015 (Preschool to Post-secondary Education)*. Putrajaya: Ministry of Education Malaysia

Muhria, L., Supriatna, N., & Nurfirdaus, N. (2023). Students' challenges of blended learning model in higher education. *J. Cor. Edu. Ling. Lit., 2*(3), 223-233.

Virani, S. R., Saini, J. R., & Sharma, S. (2023). Adoption of massive open online courses (MOOCs) for blended learning: The Indian educators' perspective. *Interact: Learn. Environ., 31*(2), 1060-1076.

Wu, T.-T., Lee, H.-Y., Li, P.-H., Huang, C.-N., & Huang, Y.-M. (2024). Promoting self-regulation progress and knowledge construction in blended learning via ChatGPT-based learning aid. *J. Educ. Comp. Res., 61*(8), 3-31.

Contribution of Postgraduate Researchers to Support Innovative Teaching and Learning for Undergraduates: Examples From the Geoscience Department, UTP

Touhid Mohammad Hossain*, Maman Hermana
Universiti Teknologi PETRONAS, Malaysia
*touhid_17006365@utp.edu.my

Introduction

Integrating postgraduate (PG) researchers into the academic framework of undergraduate teaching and learning offers a dynamic approach to education. This symbiotic relationship enriches the educational environment by leveraging the advanced knowledge and research capabilities of PG researchers to enhance the learning experiences of undergraduate students. In the Geoscience Department at Universiti Teknologi Petronas (UTP) context, this integration has fostered innovative educational practices that bridge the gap between theoretical knowledge and practical application.

This paper explores the multifaceted contributions of PG researchers to undergraduate teaching and learning. It highlights their pivotal roles in mastering and teaching advanced technologies, such as specialised software used in geoscience research. PG researchers often conduct lab sessions, workshops, and training sessions to ensure that undergraduates are proficient in the advanced computational tools for data processing. These skills are essential for the modern geoscientist, and learning them from experienced PG researchers bridges the gap between classroom learning and industry requirements.

Research in Geoscience at UTP and PG Research Program

Research in Geoscience at UTP

The Geoscience Department at UTP is at the forefront of pioneering research in petroleum geology, geophysics, environmental geoscience, computational geoscience, and sedimentology. The department emphasises interdisciplinary research, often collaborating with industry partners and international research institutions. This synergy ensures that the research is both cutting-edge and applicable to real-world challenges, bridging the gap between theoretical studies and practical applications.

PG Research Program

The postgraduate research program at UTP is designed to nurture advanced research skills and knowledge. It offers Master's and PhD programs, focusing on developing researchers who can contribute to academia and the industry. The program includes rigorous coursework, comprehensive research projects, and opportunities for publication in high-impact journals. PG researchers are encouraged to engage in innovative research that pushes the boundaries of current geoscience knowledge (Smith & Brown, 2024; Johnson, Lee & Wilson, 2024; Roberts & Green, 2023).

Contribution of PG Researchers

Mastering Technologies (Software)

PG researchers bring expertise in specialised geoscience software critical for modern geological and geophysical analysis. They often master software such as:

PG researchers bring expertise in specialised geoscience software critical for modern geological and geophysical analysis. They often master software such as,

1. Petrel: Used for reservoir modelling and simulation, allowing students to visualise and interpret subsurface data.
2. ArcGIS: Essential for spatial analysis and geographic information system (GIS) applications, helping students understand spatial relationships and patterns.
3. MATLAB: Utilised for data processing and numerical analysis, providing students with tools to handle large datasets and perform complex calculations.
4. SeisImager: Employed for seismic data processing and interpretation, which is crucial for geophysical studies.
5. Python: Widely used for its versatility in data analysis, scripting, and automation of geoscience tasks. Python's extensive libraries and ease of use make it a valuable tool for developing custom algorithms and models for geoscience data (Hossain, Hermana, & Olutoki, 2024; Hossain, Hermana, & Abdulkadir, 2023; Hossain, Hermana, & Olutoki, 2024).
6. HampsonRussell: A comprehensive suite for seismic reservoir characterisation, providing tools for inversion, AVO analysis, and geostatistical modelling (Hossain, Hermana, & Abdulkadir, 2023)
7. CMG (Computer Modelling Group): Specialised in reservoir simulation software, CMG is used to model fluid flow in reservoirs, which is vital for enhanced oil recovery and production forecasting.

By conducting workshops and training sessions, PG researchers help undergraduates become proficient in these technologies, enhancing their technical skill set and preparing them for industry demands. These sessions cover the fundamental use of the software and delve into advanced features and real-world applications, ensuring that students are well-equipped to tackle complex geoscientific problems.

By conducting workshops and training sessions, PG researchers help undergraduates become proficient in these technologies, enhancing their technical skill set and preparing them for industry demands.

Tutorial Sessions

PG researchers often lead tutorial sessions, which serve as an extension of traditional lectures. These sessions provide a platform for in-depth exploration of complex topics, fostering a more interactive and personalised learning experience [6]. During tutorials, PG researchers,

1. Facilitate Discussions: Encourage students to ask questions and engage in discussions, promoting a deeper understanding of the subject.
2. Clarify Concepts: Provide detailed explanations and practical examples, helping students grasp challenging concepts.
3. Offer Feedback: Give constructive feedback on assignments and projects, guiding academic students' academic development.

These sessions create an environment where students can actively participate in learning, enhancing their critical thinking and problem-solving skills.

Laboratory Activities

Laboratory work is fundamental to geoscience education, providing hands-on experience with scientific principles and techniques. PG researchers contribute significantly to lab activities by,

1. Designing Experiments: Developing innovative and relevant lab experiments that align with current research trends and curricular goals.
2. Supervising Sessions: Ensuring lab activities are conducted safely and effectively, providing immediate assistance and guidance to students.
3. Demonstrating Techniques: Showing students how to use advanced equipment and perform specialised procedures, enhancing their practical skills.

Their involvement ensures that lab sessions are educational, engaging, and reflective of real-world geoscience practices.

Guiding Final Year Project (FYP) Students

The final year project is a crucial component of undergraduate education, allowing students to apply their knowledge to real-world problems. PG researchers play a vital role in guiding FYP students by,

1. Mentoring: Providing one-on-one mentorship offering advice on research methodologies, data analysis, and project management.
2. Reviewing Work: Helping students refine their research proposals, analyse data, and prepare their final reports, ensuring scientific rigor and quality.
3. Facilitating Collaboration: Encouraging collaboration between students, industry partners, or other research groups, broadening their exposure and experience.

This mentorship helps FYP students produce high-quality research that contributes to the field of geoscience.

Preparing Events

Academic events such as seminars, workshops, and webinars are essential for knowledge exchange and professional development. PG researchers are often involved in organising these events, contributing by,

1. Planning and Coordination: Handling logistics, scheduling speakers, and coordinating with participants to ensure smooth execution.
2. Presenting Research: Sharing their research findings, providing valuable insights, and inspiring undergraduates.
3. Networking: Facilitating students' networking opportunities and helping them connect with experts and potential employers.

Their involvement in these events enhances the academic culture and provides undergraduates with opportunities for professional growth (Figure 1).



Figure 1 Presenting the ongoing research to the visitors from Total Energy

Lab Facilities and Lab Activities

The Geoscience Department at UTP boasts state-of-the-art lab facilities that support a wide range of research and teaching activities. PG researchers play a crucial role in maximising the use of these facilities by,

1. Maintaining Equipment: Ensuring lab equipment is appropriately maintained and calibrated, allowing for accurate and reliable results.
2. Developing New Setups: Creating new experimental setups that reflect current research trends and enhance the learning experience.
3. Conducting Safety Training: Providing safety training to undergraduates ensures lab activities are conducted safely and responsibly.

These contributions ensure that undergraduates have access to high-quality lab experiences that prepare them for future careers in geoscience.

Research Involvements

Participation in research contests is another significant area where PG researchers contribute to the undergraduates' academic and professional growth (Figure 2). These contests provide platforms for students to showcase their research skills, creativity, and innovation. PG researchers play several key roles in facilitating and guiding students through these contests: Research Projects: Involving in ongoing research projects, providing them with hands-on experience and exposure to advanced research techniques.

Sharing Sessions and Routine Activities in the Center of Subsurface Imaging (CSI)

In addition to their research roles, every month, CSI organises the "GeoInsight Exchange Series," a monthly sharing session to enhance



Figure 2 PG researchers participating and supporting the undergrad contestants in the Young Professional Technical Event, a contest organised by SEG.



Figure 3 Sharing session of GeoInsight Exchange Series at CSI, Geoscience, UTP

collaboration and knowledge exchange among CSI researchers (Figure 3). All the PG researchers serve as invited speakers in rotation to share their specialised expertise. These talks often focus on niche areas of geoscience, providing the audience with in-depth knowledge that complements the broader curriculum. PG researchers also participate in routine activities at the (CSI), such as,

1. Conducting Training Sessions: Offering training sessions on various topics, from technical skills to research methodologies.

2. Mentoring Student Projects: Providing guidance and support to students working on innovative projects, helping them achieve their goals.
3. Organising Innovation Challenges: Planning and executing innovation challenges that encourage student creativity and problem-solving.

These activities promote a culture of innovation and continuous learning, enriching the undergraduate experience.

Conclusion

The contributions of PG researchers to the Geoscience Department at UTP are multifaceted and invaluable. Through mastering advanced technologies, leading tutorials and lab activities, guiding FYP students, and organising academic events, PG researchers significantly enhance the undergraduate learning experience. Their involvement bridges the gap between research and teaching and fosters an innovative and collaborative academic environment. As UTP continues to prioritise research excellence and educational innovation, the role of PG researchers will remain crucial in shaping the future of geoscience education.

References

Hossain, T. M., Hermana, M., & Abdulkadir, S. J. (2023). Epistemic uncertainty and model transparency in rock facies classification using Monte Carlo dropout deep learning, *IEEE Access, 11*, 89349-358. Doi:10.1109/ACCESS.2023.3307355.

Hossain, T. M., Hermana, M., & Olutoki, J. O. (2024). 'Porosity prediction and uncertainty estimation in tight sandstone reservoir using non-deterministic XGBoost,' *IEEE Access, 12*, 139358-367, Doi: 10.1109/ACCESS.2024.3462824.

Hossain, T. M., Hermana, M., & Olutoki, J. O. (2024). A novel stochastic CatBoost Based shear wave velocity prediction and uncertainty analysis in sandstone reservoir using multi-seismic attributes,' *IEEE Access, 12,* 139358-367, Doi:10.1109/ACCESS.2024.3462824.

Johnson, M., Lee K., & Wilson, P. (2024). Research approaches in master-based teacher education programs: Bridging theory and practice*, Frontiers in Education*, *12*, 1-15.

Roberts, L. & Green, T. (2023). PGR Connections: Using an online peer-learning pedagogy to support postgraduate research students' academic and professional development, *Teaching in Higher Education*, *29*(1), 78-95.

Smith, J., & Brown, R. (2024). A small-group tutorial model enhances postgraduate tutors' and tutees' academic experience, *Journal of Higher Education Research*, *45(*2), 123-135.

Assessing Student Perceptions of Diversity Awareness and Inclusion Practices at Universiti Teknologi PETRONAS

Hafizan Mat Som*, Nur Syadhila Che Lah
Universiti Teknologi PETRONAS, Malaysia
*hafizan.msom@utp.edu.my

Introduction

In higher education, diversity and inclusion have emerged as critical factors influencing the quality of learning environments and students' success. These principles ensure that differences in race, ethnicity, gender, socioeconomic status, and other factors are recognised, valued, and integrated into institutional policies and practices. This study focuses on Universiti Teknologi PETRONAS (UTP), a leading university in Malaysia, where efforts to promote diversity and inclusion have been ongoing. However, a gap remains in understanding how students perceive these initiatives. This research aims to assess students' awareness of diversity initiatives, their experiences of inclusivity in classroom settings, and their overall satisfaction with the university's diversity-related policies. Diversity is a multifaceted concept encompassing various dimensions, such as race, gender, ethnicity, and cultural background. At the same time, inclusion refers to creating environments where these differences are respected, valued, and embraced. In higher education institutions, diversity contributes to a richer educational experience, exposing students to various perspectives that broaden their understanding and critical thinking. Meanwhile, inclusion ensures that all students feel valued and empowered to participate fully in academic and social activities, irrespective of their backgrounds.

At UTP, several initiatives have been implemented to foster diversity and inclusion. These include policies promoting equity, cultural exchange programs, and events celebrating diversity within the student body. Despite these efforts, questions remain about the effectiveness of these initiatives in meeting students' needs and expectations. This study's problem is the lack of data-driven insights into student perceptions of these diversity initiatives, which is essential for understanding how well they function and identifying improvement areas. A comprehensive assessment of students' awareness, experiences, and satisfaction with UTP's diversity efforts will provide valuable information that can be used to enhance these initiatives.

Literature Review

The literature on diversity and inclusion in higher education highlights the need for institutions to engage diverse student populations actively. Gibson et al. (2016) emphasised that underrepresented groups often face exclusion despite diversity efforts, calling for more inclusive practices prioritising student voices. Sanger (2020) examined Asian higher education, stressing the importance of integrating diversity into pedagogy and curriculum to enhance student learning experiences. Proactive inclusion, particularly in the classroom, can improve creativity

and problem-solving skills, but institutions must fully incorporate diverse perspectives to leverage the benefits of a multicultural academic environment.

Institutional strategies play a crucial role in promoting diversity. Tamtik and Guenter (2020) analysed Canadian universities' policies, identifying key equity, diversity, and inclusion strategies such as political commitment and student recruitment. They found that universities with dedicated diversity offices are more proactive in implementing these strategies. Varga et al. (2021) noted gaps in diversity initiatives, hindered by resource limitations and faculty resistance, stressing the need for ongoing evaluation and refinement of strategies.

Carew et al. (2024) proposed a framework for assessing equity, diversity, and inclusion in higher education, advocating the transition from philosophical ideals to practical action. In addition, Rajesh and Sujathamalini (2024) echoed this, identifying faculty training and policy evaluation as essential for promoting inclusivity. On the other hand, enhancing diversity through governance was explored, revealing that strong management improves inclusion outcomes. Additionally, the importance of stakeholder involvement in developing equity, diversity, and inclusion practices was emphasised, and a disconnect between institutional diversity representations and staff experiences was identified. It suggests better alignment between policy and practice (Iniesto & Bossu, 2023; Makuve, 2024; Richards et al., 2023).

Research Methodology

This research adopts a mixed-methods approach, incorporating quantitative and qualitative data collection techniques to understand students' perceptions better. A survey was administered to 50 students, selected through convenience sampling to represent the diverse population at UTP. The sample included local Malaysian students and international students from various academic disciplines. This approach allowed the study to capture multiple perspectives on diversity and inclusion.

The survey consisted of two main components: closed-ended questions to gather quantitative data on awareness and satisfaction and open-ended questions to collect qualitative insights into students' experiences and suggestions for improvement. The closed-ended questions used Likert scales to measure levels of awareness, satisfaction with inclusion practices, and perceptions of classroom inclusivity. The open-ended questions were designed to provide a deeper understanding of students' challenges related to diversity and inclusion and their views on how the university could improve its practices.

Quantitative data were analysed using descriptive statistics, such as frequencies and percentages, to summarise the responses. Qualitative data were analysed using thematic analysis, identifying recurring themes and response patterns. This method allowed for extracting key insights into students' experiences with diversity and inclusion at UTP.

Results and Discussions

The study revealed several key findings regarding students' perceptions of diversity awareness and inclusion practices at UTP. First, awareness of diversity initiatives at the university was found to be moderate to high among students. Approximately 45% of respondents reported being "very aware" of UTP's diversity initiatives, while 30% indicated they were "moderately aware". However, 25% of students reported being "somewhat aware" or "not aware at all", suggesting that gaps in communication and outreach efforts must be addressed. When it came to classroom inclusivity, the results were

mixed. Half of the respondents (50%) felt that classroom environments at UTP were inclusive and that their perspectives were valued, while 30% reported feeling only somewhat included. The remaining 20% felt excluded, particularly international students who cited language barriers as a significant challenge. Some students reported that using local languages in classroom discussions and group activities made it difficult for them to participate fully, leading to feelings of isolation and exclusion. This highlights the need for more consistent use of English, the primary medium of instruction, in academic settings to ensure that all students can engage fully in classroom activities.

The study also examined students' perceptions of the effectiveness of UTP's diversity-related programs and events. While 40% of respondents rated these programs as effective, 30% felt they were only somewhat effective, and another 30% considered them ineffective. These results suggest that while there are positive aspects to UTP's diversity efforts, there is still significant room for improvement. Many students indicated that the programs could be more interactive and inclusive, with opportunities for students from different backgrounds to collaborate and engage with one another on a deeper level. Cultural events, while appreciated, were seen as insufficient in fostering true inclusivity, with some students calling for initiatives that promote sustained intercultural interaction rather than one-off events.

The findings also revealed that students' overall satisfaction with UTP's diversity and inclusion efforts was moderate. Sixty percent of students reported being satisfied or very satisfied with the university's initiatives, while 25% were neutral, and 15% were dissatisfied. The dissatisfaction was primarily due to a perceived lack of representation and support for certain groups, such as international students and students with disabilities. Some students expressed concerns about favouritism and the uneven application of diversity policies, which they felt undermined the university's commitment to creating an inclusive environment.

Several challenges to inclusivity were identified through the qualitative data. Language barriers were a recurring theme, particularly for international students, who reported difficulties integrating into the campus community due to the use of local languages in informal and academic settings. Cultural differences were also cited as a barrier, with some students feeling that their cultural backgrounds were not fully understood or respected by their peers and faculty. Another challenge highlighted by students was the lack of representation of minority groups in classroom content. Some students felt that the curriculum did not adequately reflect the diversity of the student body, with limited examples and case studies from non-Western or minority perspectives. In addition, students called for more diverse representation in university leadership roles, as they felt this would help create a more inclusive and representative environment.

To address these challenges, students provided several suggestions for improvement. One of the most common recommendations was to increase the visibility and accessibility of diversity initiatives. Many students felt that UTP's efforts were not widely advertised and that more could be done to promote awareness of these initiatives, mainly through social media, campus events, and direct communication from the university administration. Another key suggestion was to enhance classroom inclusivity by incorporating more diverse perspectives into the curriculum and ensuring that all students feel their contributions are valued. Students recommended that lecturers be trained on inclusive teaching practices and that they actively engage all students in discussions, particularly those from underrepresented groups. Additionally, students called for the introduction of mentorship programs to support international students and other minority groups, helping them navigate the challenges of adapting to a new academic and cultural environment.

The findings of this study have significant implications for both UTP and the broader

higher education community. By providing a comprehensive assessment of student perceptions of diversity and inclusion, this research offers valuable insights into current initiatives' effectiveness and identifies areas for improvement. The recommendations provided by students, such as improving communication, promoting inclusive teaching practices, and addressing language and cultural barriers, can serve as a guide for university administrators as they seek to enhance diversity and inclusion on campus.

Moreover, this research contributes to the broader discourse on diversity and inclusion in higher education, offering insights that can be applied to similar institutions worldwide. As universities grapple with the challenges of creating inclusive environments, studies like this provide evidence-based recommendations that can help shape policies and practices to ensure that all students feel valued and supported regardless of their background.

Conclusion

In conclusion, while UTP has made strides in promoting diversity and inclusion, there is still work to do to ensure it is fully effective. By addressing the challenges identified in this study and building on the strengths of its current initiatives, UTP can continue to foster an inclusive and supportive educational environment that benefits all students. Through continuous assessment and refinement of diversity policies, the university can ensure that it remains a leader in promoting equity and inclusion in higher education.

Acknowledgment

The authors would like to acknowledge the grant funder, Short Term Internal Research Funding (STIRF-015LA0-053), UTP, for funding this research paper and publication.

References

Carew, P. J., Shanahan, B. W., & Doyle-Kent, M. (2024). From Philosophy to Praxis: A Framework for Investigating Equality, Diversity and Inclusion Manifestation in Higher Education Institutions. *IFAC-PapersOnLine, 5*8(3), 26–31. Doi:10.1016/j.ifacol.2024.07.119

Gibson, S., Baskerville, D., Berry, A., Black, A., Norris, K., & Symeonidou, S. (2016). "Diversity" "Widening Participation" and "Inclusion" in Higher Education: An International study. *Widening Participation and Lifelong Learning, 18*(3), 7–33. Doi:10.5456/wpll.18.3.7

Iniesto, F., & Bossu, C. (2023). Equity, diversity, and inclusion in open education: A systematic literature review. *Distance Education, 44*(4), 694–711. Doi:10.1080/01587919.2023.2267472

Makuve, N. (2024). Contemporary Issues in Higher Education: Diversity, Inclusion, Management and Governance. *African Journal of Education and Practice, 10*(1), 56–65. Doi:10.47604/ajep.2487

Rajesh R., & Sujathamalini J. (2024). Promoting Diversity and Inclusion in Higher Education: Strategies and Best Practices. *Educational Administration Theory and Practice, 30*(4), 6997–7007.

Richards, K., Pilcher, N., Galbrun, L., Forster, A., & Richards, J. (2023). Diversity and inclusion in UK Higher Education: staff perspectives on institutional representations and their reality. *Research in Post-Compulsory Education, 28*(4), 647–669. Doi:10.1080/13596748.2023.2253654

Sanger, C. S. (2020). Diversity, Inclusion, and Context in Asian Higher Education. In *Diversity and Inclusion in Global Higher Education: Lessons from Across Asia* (pp. 1–28). Springer Singapore. Doi:10.1007/978-981-15- 1628-3_1

Tamtik, M., & Guenter, M. (2020). Policy Analysis of Equity, Diversity and Inclusion Strategies in Canadian Universities – How Far Have We Come? *Canadian Journal of Higher Education, 49*(3), 41–56. Doi:10.7202/1066634ar

Varga, A., Vitéz, K., Orsós, I., Fodor, B., & Horváth, G. (2021). Diversity and Inclusion in Higher Education. *Képzés És Gyakorlat, 19*(1–2), 70–81. Doi:10.17165/tp.2021.1-2.7

Enhancing Civil Engineering Education: A Student-Centred Framework for Integrating Adjunct Lectures and Site Visits

Bashar S. Mohammed
Universiti Teknologi PETRONAS, Malaysia
bashar.mohammed@utp.edu.my

Introduction

Integrating theory and practice in engineering education is essential to bridge the gap between academic knowledge and industry expectations. Activities like adjunct lectures and site visits help students gain professional skills, practical exposure, and a deeper understanding of engineering concepts. Adjunct lectures provide insights from industry experts, while site visits allow students to observe real-world applications, fostering problem-solving skills and professional development Jonassen et al. (2006). Addressing this gap through curriculum improvements ensures graduates are job-ready and competent in handling complex engineering challenges. A framework to integrate and evaluate such activities can support educators in enhancing their effectiveness.

Methodology

The methodology comprised three stages. First, a survey was distributed to 70 civil engineering students across different academic years, collecting feedback on adjunct lectures and site visits regarding their professional skill development. The survey included demographic data, objective (multiple choice), and subjective (short answer) questions. Second, responses were analysed quantitatively and qualitatively, with thematic grouping developed through interviews. Finally, a student-centred framework was created to integrate these activities into the curriculum for experiential learning. Sixty students participated, providing insights to enhance the practical relevance of adjunct lectures and site visits.

Data Analysis

A survey of 60 civil engineering students highlighted the effectiveness of adjunct lectures and site visits, with 93.3% supporting their integration to enhance theoretical understanding, motivation, and experiential learning.

Development of Framework

The following sections briefly describe farmwork development to integrate site visits and adjunct lectures into the engineering curriculum.

Hierarchy Model

A hierarchy model based on Bloom's Taxonomy has been developed, encompassing three levels: knowledge, comprehension, and application. The first year focuses on fundamental skills and moral decision-making in engineering projects, emphasising their socioeconomic, cultural and

sustainability impacts. The comprehension stage (second year) aids skill application in real projects, while the application stage (third and fourth years) ensures students effectively apply these skills. Courses to be selected for smooth progression, such as engineering mechanics (first year), structural analysis (second year), reinforced concrete design (third year), and civil engineering design (fourth year), aligning theory and practical skill development.

Program Outcomes and Knowledge Profile

Engineering practice distinguishes engineering degrees from applied sciences, emphasising activities like adjunct lectures and site visits. Adjunct lectures and site visits directly contribute to attaining Program Outcomes (PO6, PO7, PO8), focusing on societal, environmental, and ethical impacts. These align with EAC 2020's knowledge profile (WK7), promoting theory, system interactions, moral concepts, and motivation EAC (2020).

Delivery Model

A structured approach integrates Adjunct lectures and site visits to develop students' competencies across academic years: introduction (first year), focused exploration (second year), and advanced application (third and fourth years). Phase gates assess competency progression, incorporating feedback from students, educators, and industry to continuously improve Adjunct lectures and site visits effectiveness.

Assessment Model

Figures Competency development and assessment require linking knowledge and skills with evidence of attainment. The Evidence-Centered Design (ECD) model will focus on validity and reliability. ECD identifies competencies, defines proof of mastery, and designs tasks to elicit and assess these competencies effectively.

Conclusion

The study successfully integrated adjunct lectures and site visits into the civil engineering curriculum, bridging theory and practice, enhancing student engagement, and fostering career readiness through a structured, industry-aligned framework.

References

Engineering Accreditation Council, Board of Engineers Malaysia (2020). *Engineering Programme Accreditation Standard 2020*. Rev. No. 7, BEM/RD/ACC/01. https://eac.org.my/v2/wp-content/uploads/2022/09/EAC-Standard-2020.pdf

Jonassen, D., Strobel J., Lee C. B. (2006). Everyday Problem Solving in Engineering: Lessons for Engineering Educators, *Journal of Engineering Education; 95*(2), 139.

How to Plan and Conduct A Physical Field Trip to Enhance Student Learning Experience

Yin Fong Yeong
Universiti Teknologi PETRONAS, Malaysia
yinfong.yeong@utp.edu.my

Introduction

The field trip is a tour conducted by a group of students and educators to a place away from their standard learning atmosphere. From the educational point of view, direct observation and an enhanced learning process can be achieved by conducting field trips to visit an area outside of the classroom (Field, 2025; Educational School Trips, 2025). Moreover, a field trip is one of the best approaches to provide every student with a real-world learning experience. When students leave the lecture theatre, they can experience the relationship between the textbooks' theory and the actual industry environment (Bagus, 2025). In addition, physical field trips can improve the connection between all students and strengthen their knowledge and skills (Field, 2025; Educational School Trips, 2025).

According to NEA Member Benefits (2022), a study found that regardless of gender and ethnicity, students who experience field trips can achieve better grades (59%) and higher graduation rates from high school (95%) and college (63%). Furthermore, 89% said field trips had a positive, lasting impact on their education and career because the trips caused them to be more engaged, knowledgeable, and interested (NEA Member Benefits, 2022).

Therefore, the educator/instructor needs to plan the field trip efficiently. Based on the report written by the National Park Service (2023), there are 10 quick tips to be referred for planning an effective field trip as follows,

1. Plan everything well in advance.
2. Use pre-visit activities.
3. Develop clear learning objectives.
4. Chaperoning is not a spectator sport.
5. Give everyone name tags.
6. Keep the students engaged.
7. Keep students accountable for learning.
8. Encourage independent observation time.
9. Bring the experience back home.
10. Use evaluations and sharing.

Meanwhile, other vital tips shared by NEA Member Benefits (2022) for successful planning field trips include,

1. Look around your region for interesting day trips.
2. Do your homework.
3. Follow protocol.
4. Involve your students in the preparation.
5. Make trips relevant to classroom instruction.
6. Incorporate technology.
7. Engage the senses.
8. Fundraise to cover any extra costs.
9. Follow up on the lessons learned.

Furthermore, as an educator/instructor, a clear roadmap and engaging itinerary are essential in planning the field trip. Besides,

designing field trip schedules that can provide intellectual encouragement and practical learning opportunities is crucial. Therefore, a deeper understanding and retaining knowledge among students can be achieved [studnettravel.pro, 2024].

Since physical field trips benefit students in different ways, this paper mainly shares the experience of planning and embedding them during the teaching semester as one of the most efficient pedagogies in the teaching and learning process. The methodology for conducting the physical field trip is first explained. Then, the student's assessment outcomes are discussed and analysed. Then, challenges are highlighted.

Research Methodology

Figure 1 shows the process flow for the preparation of physical field trips. It first involved selecting the host company, requesting visit approval from the host company, preparing a memo and proposal, which included the budget, visit date, visit schedule, and number of participants, and requesting approval from the department chair. After the proposal was approved, the next step involved the bus, meal arrangement, and souvenir preparation. After that, a briefing session will be conducted with students regarding the attire, gathering point and time, and overall visit itinerary.

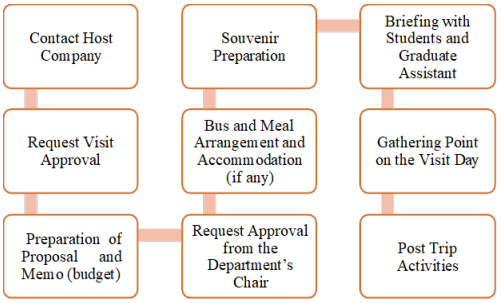


Figure 1 Planning a physical field trip

Meanwhile, accommodation arrangements might be involved depending on the chosen host company to be visited.

Assignment (Post-trip Activities)

Assignment questions are prepared accordingly to achieve the learning outcome and objective of the teaching subject and process heat transfer. The group assignments can be implemented if the field trip aims to achieve the learning outcomes from different teaching subjects in the same cohort. After students return from the physical field trip, they must answer and submit the assignment in a given timeline. Usually, a certain coursework mark percentage will be allocated for the assignment to ultimately measure the course learning outcome. Figure 2 shows the examples of individual and group

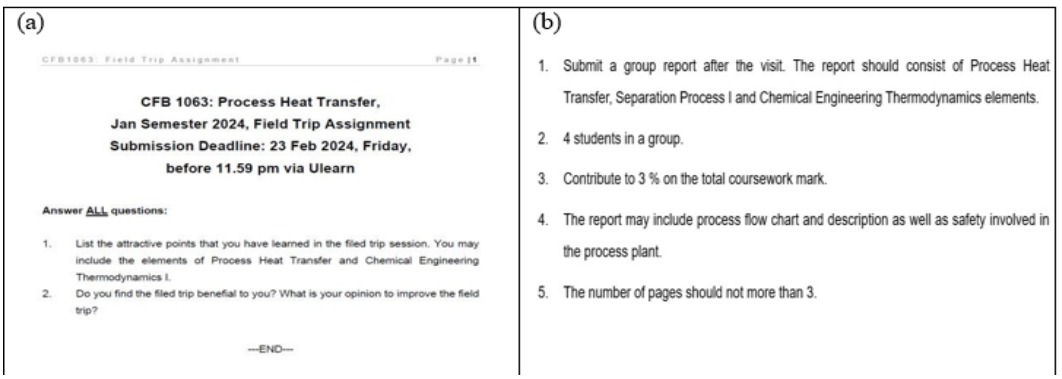


Figure 2 Examples of (a) an individual assignment and (b) a group report following the field trip

assignments given to the students.

Results and Discussion

Activities During the Visit

Figure 3 shows photos taken during the plant visit. Generally, the visit starts with a briefing on safety and process plant operation for all visitors. After that, questions and answers will be conducted to enhance the process plant knowledge for students. In this session, students will raise questions accordingly to understand the operation of the plant further and relate their chemical engineering knowledge learned from the class to the process plant. Overall, students enjoyed this session, and the knowledge they obtained will further help them work on the integrated project between Process Heat Transfer and Chemical Engineering Thermodynamics I.

Challenges

Table 1 summarises the challenges found while conducting the physical field trip. Generally, different types of challenges were encountered for field trips. Firstly, bus availability is the common challenge faced during the planning of the trip. However, the problem can be resolved by booking the bus outside UTP if the internal bus is fully occupied on the visit date. Another challenge is the large number of students (>40) in the class. This challenge can be overcome by arranging the trip a few times to ensure all students can join the trip to enhance learning experiences. On top of that, the number of graduate students involved in the trip will also be increased. Plant emergency shutdown on the visit day is another challenge in the field trip. In this context, students could not experience the plant tour during the visit. Besides, due to the confidentiality of the process plant, necessary information will not be shared during the visit. Another challenge is the response of students. Sometimes, only a few students will respond during the question-and-answer session. Therefore, the educator facilitates the question-and-answer session to enhance student interaction with the host company's instructor.



Figure 3 Photos taken during the field trip

Table 1 Challenges encountered for the physical field trip

Bus availability
Students did not turn-up during the visit day
Large number of students
Student extra requests
During the visit journey
Plant shut down/emergency
Students provide minimum response during the Q & A session

Outcome of Student Assessments

After the field trip, all students must submit assignments or group projects, contributing 1-2% of the total coursework mark for the Process Heat Transfer subject. Table 2 shows examples of students' answers for the assignments. Generally, different feedback has been received from the students to improve the field trip. Overall, field trips benefit all students through various learning experiences.

Table 2 Student's assignment answer

"I find that this field trip is beneficial for me and it was a very informative session. I could better understand how subjects that have been studied can relate to a plant."
"During the field trip, I witnessed first-hand how the principles of Process Heat Transfer are applied in different industries."
"In conclusion, the field trip was an amazing opportunity for personal growth and reflection, as I was exposed to new experiences and perspectives."
"In any case, I believe I speak for everyone when I say that we are grateful for such a trip and grateful to our lecturers for planning it for us."

Conclusion

Proper planning is vital to achieving a successful physical field trip. Different steps and challenges might be encountered depending on the chosen company for the visit. It is always beneficial to students to organise a field trip, as it serves as one of the innovative ways to attract students' attention for an effective teaching and learning process and to achieve the learning outcome of the teaching subject. Students will always be encouraged to learn outside the classroom and experience the real working environment before graduation.

Acknowledgement

The author would like to thank the Department of Chemical Engineering, UTP's financial support, and the technical support of the host companies for the field trips.

References

Bagus, B. (2025). The Importance of Field Trips in a Well-Rounded Education Process. Upskill study. https://upskill.study/the-importance-of-field-trips-in-a-well-rounded-education-process

Educational School Trips (2025). The importance of educational trips in teaching and learning. https://www.educationalschooltrip.com/

Field. (2025). Field Trip: Definition & Benefits. Study.com. https://study.com/academy/lesson/field-trip-definition-benefits.html.

National Park Service (2023). Ten Tips for a Successful Field Trip. https://www.nps.gov/articles/field-trip-tips.htm.

NEA Member Benefits (2022). How Field Trips Boost Students' Lifelong Success. https://www.neamb.com/work-life/how-field-trips-boost-students-lifelong-success

Studenttravelpro, (2024). https://studenttravel.pro/student-travel-planning-guide

Metaverse in Education: Enhancing ESL Students' Learning Experience through Virtual Psychogeographical Exploration

Mohd Fadhli Shah Khaidzir*[1], Mafarhanatul Akmal Ahmad Kamal[2]
[1]Universiti Kebangsaan Malaysia, Malaysia
[2]Universiti Teknologi MARA, Malaysia
*cali.khaidzir@ukm.edu.my

Introduction

In today's world of immersive learning through technologies like augmented reality (AR) and virtual reality (VR), students have enhanced and accessible learning experiences. Strong language skills are essential for students to share their ideas and connect with others effectively. Engaging in virtual learning becomes increasingly important as they navigate a borderless world through social media and online platforms. Creativity and critical thinking are vital to thriving online and in real life. Leveraging cutting-edge tools like the metaverse can further enhance students' potential across various learning domains, enabling the exploration of concepts through creative and imaginative lenses. Therefore, providing students with dynamic and engaging learning experiences that foster critical and creative thinking is vital.

Related Work/Literature Review

In Malaysia, the emphasis on rote learning frequently hinders the development of critical and creative thinking skills. However, reinforcing reflective practices can help students take responsibility for their knowledge and become self-directed, enhancing their personal and academic growth (Aizan et al., 2021). Moreover, practical communication skills and critical thinking are vital for navigating virtual and physical contexts, allowing students to manage information efficiently and adapt to social transformations (Cui & Teo, 2023). Using the Psychogeography approach by Debord (1955), walking exploration promotes meaningful experiences as students engage with, respond to, and reflect on their surroundings. Mohd Fadhli Shah et al. (2022) contend that this approach enables individuals to explore places more meaningfully and embark on a process of reflection.

Thus, leveraging metaverse technology can enhance learning by promoting self-directed learning, creativity, and critical thinking through reflective virtual experiences. Makransky and Mayer (2022) state that higher immersion in learning leads to a more significant presence, increasing enjoyment, and improving academic performance. This aligns with Dale (1969), who emphasised the importance of experiential learning, where learners retain information better through hands-on activities. Hwang et al. (2023) argue that learning should not be limited to physical classrooms, as technology offers experiential learning opportunities. The metaverse allows students to engage in experiential learning, enhancing communication, creativity, and critical thinking through virtual explorations.

Research Methodology

A mixed-methods approach was employed to explore students' engagement in virtual walking experiences on a metaverse platform using a psychogeographical approach with a convenience sample of 21 participants. Participants were instructed to explore a virtual classroom environment on a metaverse platform using the provided link, facilitating independent learning by offering accessible information and learning materials. The metaverse virtual classroom features various 'portals' that allow students to engage with different spaces using the Psychoanalytic walking concept, which consists of six steps: move, observe, notice, collect, analyse, and reflect. Participants were free to explore the classroom independently, based on their preferences and interests. While doing so, they engaged with their surroundings through language by utilising multiple senses, such as visual and auditory, facilitating their observation and interpretation of their surroundings.

After the exploration, participants were requested to complete a questionnaire to evaluate their perception of the psychoanalytic walking concept in the metaverse. The questionnaire was adapted from Hwang et al. (2023) and consisted of two demographic questions and 17 items on participants' psychogeographical walking experience on the metaverse platform. The data were analysed using SPSS Version 28 for descriptive and inferential analysis. Cronbach's alpha was calculated for the reliability result, and the questionnaire exhibited excellent reliability, with a value of .954.

Result and Discussions

The findings assess students' engagement and exploration of the metaverse during their Psychogeographical walking journey.

Table 1 Students' engagement and exploration

Statements	Mean	Std. Deviation
C1. Recommendation and Future Use	4.26	0.61
C2. Learning and Achievement	4.19	0.69
C3. Comfort and Convenience	4.14	0.76
C4. Interest, Enjoyment, and Engagement	4.07	0.82
C5. Socialisation and Interaction	4.07	0.75
C6. Satisfaction and Confidence	4.00	0.88
Overall	4.12	0.75

Table 1 summarises students' perceptions of the Psychogeographical walking experience on the metaverse platform across six categories (C1-C6). The highest average score was for C1 (M = 4.26, SD = 0.61), signifying strong student support for this approach in future learning. C2 (M = 4.19, SD = 0.69) and C3 (M = 4.14, SD = 0.76) also received high scores, reflecting positive perceptions of the experience and its accessibility. C4 and C5 had mean scores of 4.07 with low standard deviations, indicating consistent positive responses and excellent user experience. Although C6 received a lower mean score (M = 4.00, SD = 0.88), it remained above average, suggesting overall satisfaction despite some variability in confidence levels. Overall, the integration of the Psychogeographical walking experience with the metaverse platform was well received, as reflected in the overall mean score of 4.12.

Furthermore, Pearson correlation analysis reveals no positive relationship between students' prior experience with the metaverse and their psychogeographical walking

experience on the metaverse platform ($r = -0.075$, $p = 0.747$).. This indicates that whether or not someone has prior exposure to metaverse activities, there is virtually no linear relationship with the meaningfulness of their psychogeographical walking exploration. Nonetheless, most students enjoy experiencing new cultures and technology through metaverse psychogeographical walking explorations, with an average mean rating of 4.12.

Conclusion

Implementing technology in education through a metaverse platform for language learning offers a transformative approach that enhances students' overall learning experience and performance. By integrating psychogeographical walking exploration, students immerse themselves in diverse language and cultural environments, fostering more profound engagement, heightened interest, and improved language skills. Consequently, virtual Psychogeographical exploration on the metaverse platform enriches students' understanding of language in real-world scenarios while cultivating critical thinking and creativity, making language learning more dynamic and effective.

Acknowledgement

The authors would like to thank everyone who contributed to this study.

References

Cui, R., & Teo, P. (2023). Thinking through talk: Using dialogue to develop students' critical thinking. *Teaching and Teacher Education, 125*, 104068.

Dale, E. (1969). *Audio-visual Methods in Teaching*. Third Edition, New York: Dryden Press

.

Debord, G. (1955). Introduction to a critique of urban geography. In H. Bauder & M. Salvatore (eds.), *Critical Geographies: A Collection of Readings* (pp. 23-27). Praxis ePress.

Hwang, Y., Shin, D., & Lee, H. (2023). Students' perception on immersive learning through 2D and 3D metaverse platforms. *Educational Technology Research and Development, 71*(4), 1687-1708.

Makransky, G., & Mayer, R. E. (2022). Benefits of taking a virtual field trip in immersive virtual reality: Evidence for the Immersion Principle in multimedia learning. *Educational Psychology Review, 34*(3), 1771-1798.

Shah Khaidzir, M. F., Hashim, R. S., & Md. Yusof, N. (2022). A psychogeographical experience between the self and the place. J*ournal of Nusantara Studies, 7*(1), 243-263.

Yaacob, A, Ratnawati M. A., Hussain, R. M. R. & Ismail, S. N. . (2021). Empowering learners' reflective thinking through collaborative reflective learning. *International Journal of Instruction, 14*(1), 709-726.

Laboratory Experiences Supplement and Stimulate Materials Science for Chemical Engineering (MSCE) Class

Noridah Osman
Universiti Teknologi PETRONAS, Malaysia
noridah.osman@utp.edu.my

Introduction

As educational activities become more versatile, new innovative pedagogy encompasses the available resources through engaging pedagogy and technology to serve the learning process. Nonetheless, various limitations still exist since specific course topics are better delivered through an integrated system rather than one single system. The design of the learning system, which integrates content and technology effectively and efficiently and is delivered asynchronously, synchronously, or both, is preferred in this case (Kusmawan, 2022).

The specific requirements and targets based on the course topic require the lecturer to create a physical learning environment with hands-on information to facilitate theoretical and efficient learning. Constraints in practical learning arise when a course must be delivered practically and conducted in a laboratory. Implementing this practical learning and laboratory-based learning activity often fails due to restricted access to equipment and facilities. Also, practical courses provide students with real-world learning experiences that encourage a natural and active learning environment. This learning constitutes necessary skills that students use to create knowledge and understanding simultaneously through their learning (Issah et al., 2023).

Based on the observation in the previous semester, we discovered that a lecturer had limited capacity to provide authentic experiences on learning the instruments even though the students have been providing a video to show the information about the instrument. At the same time, the students also experienced problems performing the practicum independently and were uneasy writing reports on this Materials Science course, specifically on topics related to materials properties and characterisation (Kusmawan, 2022). Hence, these constraints degraded the quality of course implementation.

To address the issues, we strongly agree that innovation must be directed to facilitate students with open opportunities to conduct the science practicum independently and provide intensive communication and individual from the technician who runs the lab (Wei et al., 2020). For this reason, this practice of visit ensures that the impact of physical hands-on experiences on material science and engineering undergraduate students is achieved by self-efficacy, self-concept, interest, and laboratory anxiety/ curiosity of high-end equipment in material science for chemical engineering courses (Theresa et al., 2022). We used a mixed methods approach to improve our understanding of how these factors mediate student learning. This tour shows a range of equipment, its specification, utilisation, function, and operation in one of our centres of analytical laboratories. In addition, the MURAL platform was used to determine the learning outcomes from the tour laboratory

visit with a case study in which students were required to provide solutions and suggestions and apply what they learned from the visit. The assignment to test their learning process and experiences captures both theoretical and practical components (Elizabeth et al., 2021). Thus, the class lecture-visit laboratory-case study with MURAL poster presentation was adopted. Although the potential value of using tour lab visits in higher education seems to be eradicated due to high technical and virtual reality applications, it is vital to reinstate this context, especially in situations where eye contact and naked eyes vision learning are critical options and where the costs of real laboratories cannot be afforded to take for granted. Ultimately, this study aims to determine the impact of laboratory visits to enhance student engagement and assess the effects of laboratory visits on student learning processes in a selected materials science topic for the chemical engineering module, specifically on analysis materials targeting Materials Science for Chemical Engineering (MSCE) class.

Research Methodology

The study focused on physical lab visit development and was entitled 'The implementation of physical lab-based practicum, to improve the ability of the students to apply their knowledge of the theory part and practical parts as students engage directly with the technician and instrument. Below are just some of the snapshots of students visiting the Centre of Analytical Laboratory or, in short, CAL Lab, participating in lab tours, conducting the sample preparation and engaging in the discussion.

Lab Visit Grouping and Self-learning Video

Students were divided into five groups and assigned specific equipment; nonetheless, every student will experience the following five different equipment. Every piece of equipment is attached to their self-explanatory video for the student to refer to (Table 1). The students

Table 1 CAL Lab visit oordination and information

Equipment	12:00pm – 12:20pm	12:25pm – 12:45pm	12:50pm : 1:10pm	1:15pm : 1:35pm	1:40pm :2:00pm	PIC	YouTube Link
XRD	G1	G5	G4	G3	G2	En Irwan	https://www.youtube.com/watch?v=W-kzUTDK-bUA
SEM	G2	G1	G5	G4	G3	En Suria Adam	https://www.youtube.com/watch?v=miAQM-fk-09I
TEM	G3	G2	G1	G5	G4	Pn Nor Hashila	https://www.youtube.com/watch?v=LtW5gXm-vG-M
TGA	G4	G3	G2	G1	G5	Pn Faizah	https://www.youtube.com/watch?v=7Oc_nrIks2A
DSC	G5	G4	G3	G2	G1	En Shairul	https://www.youtube.com/watch?v=LDglRx-ArS-M

were requested to watch the provided video equipment before the hands-on laboratory visit. The videos provided guided instructions and explained the underlying basic theory relevant to lab visits, thus providing a basis for supportive material. Then, each piece of equipment is run and briefed by the technical expert, the so-called laboratory's qualified and certified staff, during the visit.

Case-Study Assignment

The students were given a case study to apply the knowledge gained from the CAL visit and prepared a report in the AO poster (Figure 1). The poster was submitted to the MURAL platform for grading since feedback can be given immediately. Instruction to the student is given as per the attachment so that the report

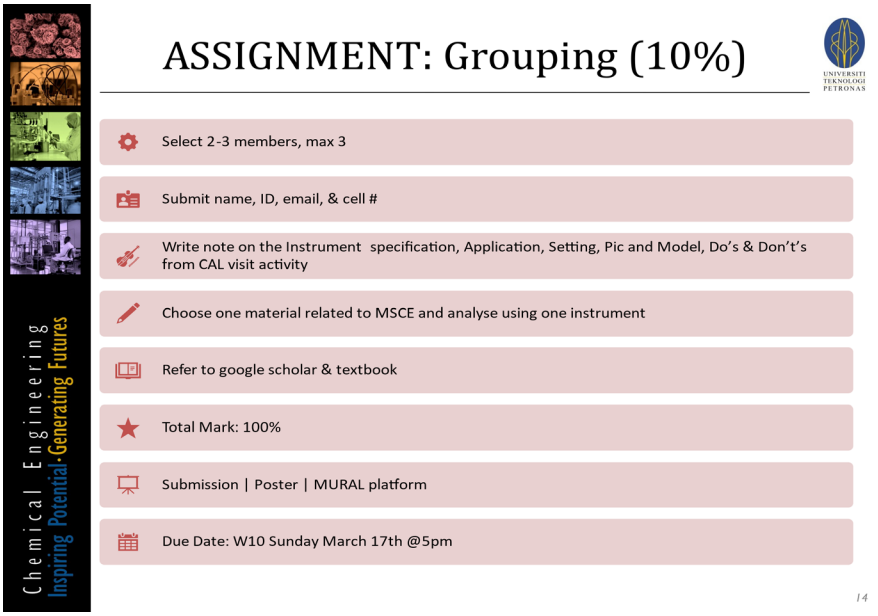


Figure 1 Instruction for the case study

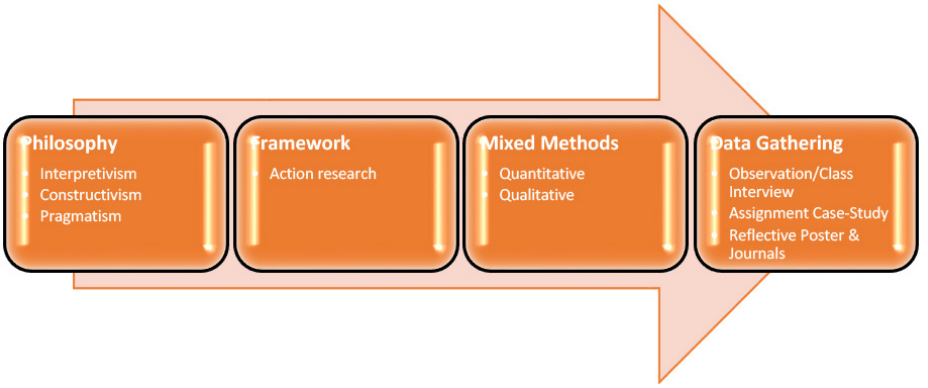


Figure 2 Research methodology

can be prepared according to standards and requirements based on the rubric (Figure 2). The student is also given a peer-review mark to evaluate their classmate's report poster.

Data Collection

The underpinning philosophies were interpretivism, constructivism, and pragmatism (Figure 2). The framework adopted was action research (AR). The AR framework incorporated a mixed-methods approach to gathering quantitative and qualitative data for this study. The triangulation component was adopted using interviews, poster interpretation, and reflective journals using three data-gathering tools.

During the lab visit session, the students observed their behaviour toward the session as the qualified and specialist staff conducted the briefing. Then, in class, the students were asked to share their views and feelings about the lab visit to capture the aspects of student engagement, behavioural engagement, emotional engagement, and cognitive engagement. Then, they were assigned to transfer and reflect on their knowledge and test their understanding by preparing a case study project and presenting via a poster presentation. Thus, the rubric on the poster is ready, and the mark distribution consists of 60% from the lecturer and 40% from their classmate (Figure 3). Students' classmate evaluations assist in determining students' reflections on the lab visit, ensuring that the content and practicality are derived from the experience. The final component involves incorporating reflections from other journals on the same techniques applied in the classroom.

INSTRUCTOR/PEER EVALUATION (40%)

Your Group Name or #:
Member Name & ID:
Poster Evaluation Name or #:
Member Name & ID:

Report rubric (100% weightage):

Category	Criteria for Judging Quality	Please award appropriate mark for each category					Marks Awarded
		Excellent	Good	Average	Below Average	Failure	
Abstract (5)	· Highlight all the important features of the report.	**A to A-** (4.0 - 5.0)	**B+ to B** (3.3 - 3.9)	**C+ to C** (2.5 - 3.2)	**D+ to D** (2.0 - 2.4)	**F** (0.0 - 1.9)	
Introduction, Background of study (10)	· Introduction, objective of the project-Instrument, selection of material case study: industry pain	**A to A-** (8.0 - 10.0)	**B+ to B** (6.5 - 7.9)	**C+ to C** (5.0 - 6.4)	**D+ to D** (4.0 - 4.9)	**F** (0.0 - 3.9)	
The Material based on class note & journal (20)	· Description of material, pain & solution	**A to A-** (16.0 - 20.0)	**B+ to B** (13.0 - 15.8)	**C+ to C** (10.0 - 12.8)	**D+ to D** (8.0- 9.9)	**F** (0.0 - 7.8)	
Potential application of instrument (20)	· Discussion on application of the instrument to the selected material, instrument setting, pic & model, do's & don't's	**A to A-** (16.0 – 20.0)	**B+ to B** (13.0 - 15.8)	**C+ to C** (10.0 - 12.8)	**D+ to D** (8.0 - 9.8)	**F** (0.0 - 7.8)	
Journal recommendation, the method to analyse and finding and associate to properties, characterisation, instrument from CAL(20)	· Journal identification, method analysis, finding which related to you instrument & material & CAL visit	**A to A-** (16.0 – 20.0)	**B+ to B** (13.0 - 15.8)	**C+ to C** (10.0 - 12.8)	**D+ to D** (8.0 - 9.8)	**F** (0.0 - 7.8)	
Market Segment or Economic View (10)	Description of market segment or economic view on the material and important of the instrument analysis	**A to A-** (8.0 - 10.0)	**B+ to B** (6.5 - 7.9)	**C+ to C** (5.0 - 6.4)	**D+ to D** (4.0 - 4.9)	**F** (0.0 - 3.9)	
	· Conclusion and Recommendation	**A to A-**	**B+ to B**	**C+ to C**	**D+ to D**	**F**	

Figure 3 Rubric for the poster by their peer

Results and Discussion

The findings from the AR study are presented thematically, according to the themes



Figure 4 Student visit to the CAL lab

of behavioural engagement, emotional engagement, and cognitive engagement, and based on the triangulation components.

Observation

This section considers how the lab visit impacted students' behaviour engagement with laboratory learning, highlighting participation and interaction (Figure 4). Participating involves taking part in an activity. Our observation showed that positive participation and involvement were reflected in the following behaviours: pre-visit preparation, attendance, active engagement during the visit, paying attention, asking questions, and making an effort to engage with the learning process. The pictures below prove that the students are very attentive.

Examining students from the engagement perspective, they were engaged in the visit, specifically during the demonstration part, indicating that most students were paying attention to the learning process. In addition, based on the feedback from the technical staff, which noted "good engagement from the students, good contributions when I posed questions, I felt most students were interested and making efforts in this lab". So, we could say their engagement level is considered high as some of them have been notified that the time for the session should be prolonged.

The interaction was understood here as 'communication or direct involvement with someone or something'. Peer-to-peer and student-visit tools interaction were predominant in this study. There was strong evidence of peer-to-peer interaction. This was evidenced by the lecturer reflecting on the poster-session evaluation and journal reflection, with recorded examples like 'nice group dynamic' and 'good teamwork'. A common point made by the group was that they were more likely to assist their peers in poster-making since having done the lab visit, they were more confident in their knowledge.

As described by the students, the poster was laid out in such,

'…the instrumentation, the sample testing, and analysis, application by the industry with dos' and don'ts were illustrated'.

The qualitative findings about the interaction with the video show that the students claimed that the video as supportive material was a great help to them as some parts of the briefing were not captured. Some students indicated that if watching the video were mandatory, more students would do it.

In terms of emotional engagement, which includes 'interest and value', interest is the feeling of the student whose attention and curiosity are engaged by the learning, and the value relates to the student's perception that a learning experience is practical, relevant, and of worth. Again, the lab visit positively impacted students' emotional engagement. Comments included, "It is beneficial to see the instrument itself. I found them interesting as I can relate with the class theory and the practical. I used the lab visit to prepare my case study and poster assignment".

From cognitive engagement, to determine the students' approach to learning and expend the mental effort to comprehend and master content as part of a sub-topic in the Materials Science for a chemical engineering course of topic 3: characterisation of materials and integration with another topic, topic 2: properties of materials. We observed that a lab visit helped us to understand how to integrate topics 2 and 3 in our MSCE course, where we determine the properties of materials we are using the instrument to characterise their properties. The majority of student agreed on this technique and increased their motivation to learn and apply.

Data from lecturer-researcher reflections journals indicate that a good portion of students have a good understanding of the underlying

theory. This is reflected in the poster, where 'interaction levels of the student with the poster was outstanding,' and most students could address all requirements (Figure 5). The students could grasp the learning process, 'it seems that many students had key understandings and concepts required'. The theory and practice were optimistic, as they mentioned, 'I just found an easy way to explain how the properties, instruments, and characterisation work'.

Significance of the Study

The findings showed that physical tour lab visits positively impacted students' self-efficacy, self-concept, interest, and scepticism. Students who expressed some curiosity about doing the lab before the course reported that the use of the tour lab visit decreased their levels of curiosity at the end of the lab, hence increasing their interest to know more and apply the application of the instrument learned, showing that their satisfaction is relatively high at the same time. The implications of these findings speak to the potential value of using tour lab visits in higher education, which is eradicated due to high technical and virtual reality applications.

From the poster presented, it was clear that the students could illustrate the equipment, its specification, utilisation, function, and operation. In addition, they could apply the purpose of the equipment to the material selection they learned in terms of characterisation and determination of properties. Figure 5 shows the utilisation of knowledge in the case study and analysis.

Because they are from engineering backgrounds, the lab visit creates a learning ground for the students to learn and know about analytical instruments. The science of art on the relation between materials and science with the elements of engineering has created a bridge between the topics with the hands-on activities of this lab visit. Furthermore, the students are from the final year batch. Hence, the visit inspired them and developed their interest in the final year project they were involved in.

Conclusion

The lab visit session set out to evaluate the technique supplement and stimulate Materials Science for Chemical Engineering students. Hence, objective one has been achieved; teaching and learning via a tour and visit to the equipment laboratory have a positive impact. In conclusion, it is crucial to acknowledge that the conception, development, and application of cross-reality laboratories with the case-study style of the report are intrinsically tied to the passion, ingenuity, and commitment of teaching philosophy who have devoted themselves to this realm. Considering the reflections on the laboratory as a teaching and learning stage here, it becomes evident that introducing cross-reality laboratories that serve as hands-on practicality in teaching is far more explicit and relevant to our students.

Acknowledgement

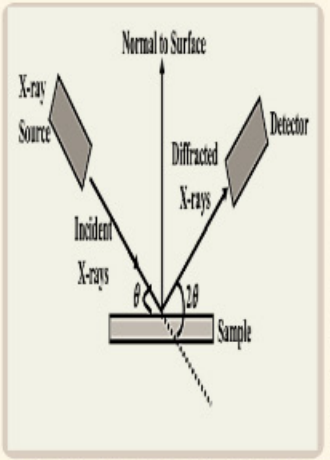
The author wishes to thank Materials Science for Chemical Engineering by the Chemical Engineering Department for offering the course to final-year students and the Centre of Analytical Laboratory for support and for accommodating the visit and briefing to our MSCE students.

XRD ANALYSIS ON CERAMIC

CEB 4022 MATERIAL SCIENCE CHEMICAL ENGINEERING

IBRAHIM (20001717)
NAIL KARIMOV (20000060)

A technique used to determine the atomic and molecular structure of a crystal, in which the crystalline atoms cause a beam of incident X-rays to diffract into many specific directions and interfere with one another. The diffracted & scattered rays that interfere with each other produces spots of difference intensities that can be recorded on film. This process is like the photon transfer in double-slit experiment.



SPECIFICATION

- Typically uses a copper (Cu-Kα) or cobalt (Co-Kα) X-ray tube.
- Energy: 100eV ~ 200keV Wavelength: 0.01 ~ 10nm
- Motorized stage for precise sample positioning.
- Rotation capability for obtaining diffraction patterns at different angles.
- Tilt adjustment for optimizing diffraction intensity.
- Scintillation or semiconductor detector.
- Two-dimensional detectors for capturing entire diffraction patterns simultaneously.
- Focusing optics to collimate and focus X-rays onto the sample.
- Anti-scatter slit to reduce background noise.
- Software for instrument control and data analysis
- Radiation shielding to protect the operator.
- Emergency shutdown mechanisms.
- Sample holders compatible with various sample geometries (powder, thin film, single crystal, etc.).



Model : Bruker's X-ray Diffraction D8-Discover Instrument.

DO'S

- Ensure cleanliness and proper mounting.
- Maintain instrument accuracy with frequent calibration.
- Adjust parameters for precise data collection.
- Improve data quality by removing noise.
- Utilize software for comprehensive data analysis.
- Prioritize safety with appropriate gear and precautions.
- Keep concise records for future reference.
- Confirm findings through replication or comparison.

DONT'S

Ensure meticulous sample preparation and regular instrument calibration to maintain accuracy.

Optimize parameters for precise data collection and subtract background noise for quality results. Thoroughly analyse data and prioritize safety by following established protocols.

Document experiments for traceability and seek guidance if uncertainties arise. Validate findings through replication and stay informed about advancements in XRD techniques for continuous improvement.

DATA ANALYSIS

X-RAY DIFFRACTION PHASE ANALYSES FOR GRANULATED AND SINTERED CERAMIC MATERIALS

Experimental Setup

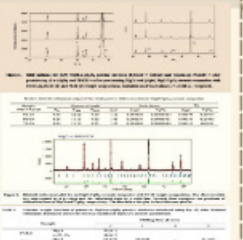
$MgO - \alpha - Al_2O_3$ powder mixture were made by ratio 1:1 MgO powder was calcined at 700 °C for 1 hour prior to mixing to remove absorbed water vapor . To introduce large grain effect, one of the powder was presented at 1000 °C for 1hour. Milling was performed using a conventional rotating milling to reduce back the identification for the powders showed that there were only two phases in the mixture, i.e. periclase (MgO) and corundum/α – Al_2O_3). Nomenclature for the samples are given as follows. Mixtures of MgO - Y_2O_3 with compositions of 90: 10, 80: 20 and 70: 30 by weight were made by conventional milling. Each mixture was then uniaxially pressed at 37 MPa to obtain green body prior to sintering at 1550°C for 3 hours. The sintering produced ceramic composites with more than 95% density. Diffraction data were collected using a diffractometer with Cu target at 40 kV and 30 mA with 2θ range of 10-120°, 0.02° step size and 1s collecting time per step.



Results & Discussion

Figures 1 display X-ray diffraction (XRD) patterns for MgO – α – Al_2O_3 powder mixtures (left) and MgO - Y_2O_3 ceramic sintered composites (right). Visual inspection presenting conditions shows no significant difference in the MgO – α – Al_2O_3 patterns, while the MgO - Y_2O_3 patterns exhibit systematic intensity changes with composition. Rietveld analysis of the XRD patterns, with key figures-of-merit (FoMs) tabulated in Table 1 for ceramic composites, yielded acceptable results according to Kisi (1994). Visual inspection of fitting plots confirms successful Rietveld refinement. Example final fitting plot for MgO - Y_2O_3 ceramic composites (90:10 composition) is shown in Figure 2, and using minor fluctuations in difference plot between calculated and observed patterns. These observations support the refinement outputs for further analyses such as phase composition and crystallite size calculations.

Table 2 displays absolute weight fractions of phases in MgO – α – Al_2O_3 powder mixtures, with MgO or α – Al_2O_3 as the standard, each constrained to 50%. Key observations include: (1) Non-pre-sintered mixtures exhibit an expected 1:1 weight composition. (2) Pre-sintering introduces bias in phase composition calculation, mitigated by milling. The original powders, with small crystallite sizes and insignificant absorption contrast, yield accurate composition results. However, pre-sintering increases crystallite size, leading to intensity reduction and inaccurate composition. Milling restores accuracy by reducing crystallite size.



For MgO - Y_2O_3 ceramic composites, Rietveld phase analysis yielded relative weight fractions (Table 3), alongside Rietveld absolute weight fractions computed using Eq. (2). However, both calculations proved inaccurate. For powder samples, due to Eq. (2) failing to fully accommodate absorptive character, resulting in biased weight fractions. Notably, rubber calculation model considers particle or crystallite size. Hence, a new model is proposed to enhance accuracy by incorporating absorption coefficients and Rietveld crystallite size. Application of this model to XRD data for MgO - Y_2O_3 ceramic composites reduced Y_2O_3 calculation bias to 1.5%, 2.1%, and 1%. This exclusive improvement underscores the model's potential, so its ongoing efforts to incorporate Eq. (4) for further enhancement. Modifications to the model proposed by Taylor and Matulis (1991) are necessary for providing absolute weight fractions of phases.

Interpretation

Original approach of Rietveld phase analysis applied to x-ray diffraction data of presintered MgO – α – Al_2O_3 powder mixtures and sintered MgO - Y_2O_3 ceramic composites gave biased relative weight fraction of phases since it does not include the micro absorption effects. The bias is even larger when calculating absolute weight fraction where crystallite size effect is not accommodated. A new empirical model has been developed to give the correct concentrations with moderate accuracy, i.e. approximately by 6%. Further work is necessary to further improve the model.

XRD SETTING

1) **Wavelength Selection:** Choose appropriate X-ray wavelength (e.g., Cu-Kα or Co-Kα)
2) **Sample Mounting:** Secure and align the sample properly on the holder or stage.
3) **Goniometer Settings:** Set angular range and rotation speed for data collection.
4) **Detector Configuration:** Choose detector setup and adjust for desired diffraction angles.
5) **Measurement Parameters:** Select mode (continuous/step scan), step size, and integration time.
6) **Environmental Control:** Maintain temperature/humidity if needed; use proper chambers for sensitive samples.
7) **Data Acquisition and Analysis:** Start data collection, monitor patterns, process data, and analyse results.
8) **Safety Precautions:** Follow safety protocols, shield radiation, and limit exposure.
9) **Instrument Calibration:** Periodically calibrate using standards for accuracy.
10) **Documentation:** Keep detailed records of settings, sample details, and results.

APPLICATION

- Identify crystalline phases and orientation.
- Determine structural properties: Grain size, Phase composition , Preferred orientation and Lattice parameters
- Measure thickness of thin films and multilayers
- Determine atomic arrangement

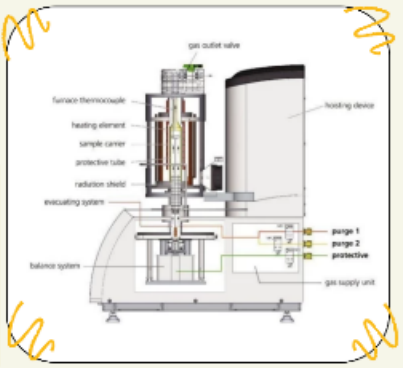
Reference Pratapa, S. (2010). X-Ray Diffraction Phase Analyses for Granulated and Sintered Ceramic Materials. *Makara Journal of Science, 11*(2), 20.

MSCE_POSTER_(IBRAHIM_20001717_&_NAIL_20000060).pdf

MUHAMMAD NAQIYUDDIN MOHAMAD FEZAR – 19001480
THOOY KOK PIN – 20001881

THERMOGRAVIMETIC ANALYSIS

Thermogravimetric Analysis (TGA) is a **material analysis technique** in which the **sample weight of a material** is evaluated as a **function of temperature or time** while the sample is **heated in a controlled environment.** As the components of the **material volatilize over time,** the **temperature and mass loss are recorded.**



Which Materials are Appropriate for TGA Testing?

TGA analysis is commonly used on polymers to identify thermal stability and the impact of fillers. Another widespread use is testing fluids, such as lubricants, for weight loss resulting from evaporation, oxidation, or thermal cracking of base fluids or formulations.

What can TGA Measures?

- Loss of water
- Loss of solvents such as volatile organic compounds
- Loss of plasticizers
- Decarboxylation
- Thermal decomposition
- Oxidation
- Weight of contaminant
- Weight as a percent of ash

OPERATIONAL MECHANISM

Thermogravimetric analysis (TGA) setup typically **comprises a sample pan supported by a precise balance within a furnace,** where the **sample undergoes heating or cooling.** Throughout the experiment, the mass of the sample is continuously monitored. To **regulate the sample environment, a purge gas is employed,** which can either be inert or reactive, flowing over the sample and exiting through an exhaust.

The instrument is controlled by the computer, where will be displaying a graph illustrating mass versus temperature, allowing for observation of the percentage of mass lost

APPLICATION

- Some more recent applications use TGA for **soil forensics** or to **characterize organic materials of plants for lakes**
- **Characterisation of pharma material**- determine the solubility and compatibility of pharmaceutical ingredients
- **Characterisation of polymer-measure** thermal stability and degradation
- **Determing fibre content** of composite- remove resin by heating
- Obtain information regarding **thermal and oxidative stability, life expectancy, decomposition profile, moisture** and **volatiles content**

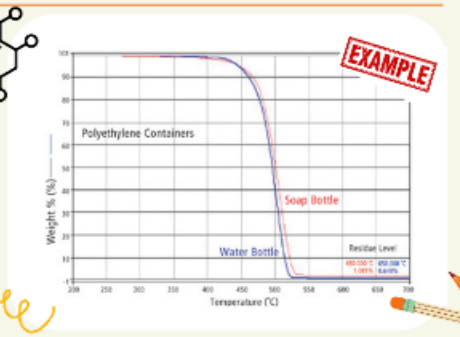
SAMPLE PREPARATION

1. First will set the initial temperature on the program tab for the analysis.
2. Then use tweezer and carefully place an empty crucible sample pan on the top of the sensor to tare empty the mass of it using Control Panel in program tab.
3. Take out the crucible pan and place sample in the crucible pan using spatula and place it back on the top of the sensor
4. Then read the weight of the sample using program tab and click start after the weighing.
5. The reading graph result will be shown on the instrument viewer.

TGA ANALYSIS ON POLYMER

A **high performance TGA**, such as the ones available from PerkinElmer, allow for the detection of subtle, but potentially important, differences between polymers. Shown in figure besides is the TGA results obtained on two different high density polyethylene (HDPE) containers. One is an opaque soap container while the other is a semitransparent water bottle. **The soap bottle HDPE resin has a slightly, but significantly, higher level of filler (2.1% versus 0.65%).** This information is important for the production of the containers.

TGA not only **evaluates how polymers and an array of other materials perform under extreme temperatures** but also provides **information about the materials used to construct a product**, including the **base polymer(s), additives, and fillers**

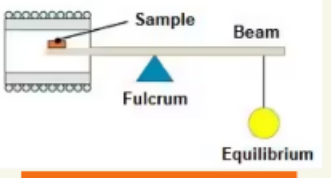


CAN DO

- Continuously monitor to ensure proper data collection
- Purge the instrument with inert gas to controll atmosphere and prevent unwanted reaction
- Clean the instrument after the experiment

CAN'T DO

- Overload the sample mass(affect accuracy
- Use contaminated sample(introduce error)
- Exceed recommended temperature limit (damage the furnace)



BASICS COMPONENTS OF A THERMO GRAVIMETRIC ANALYZER

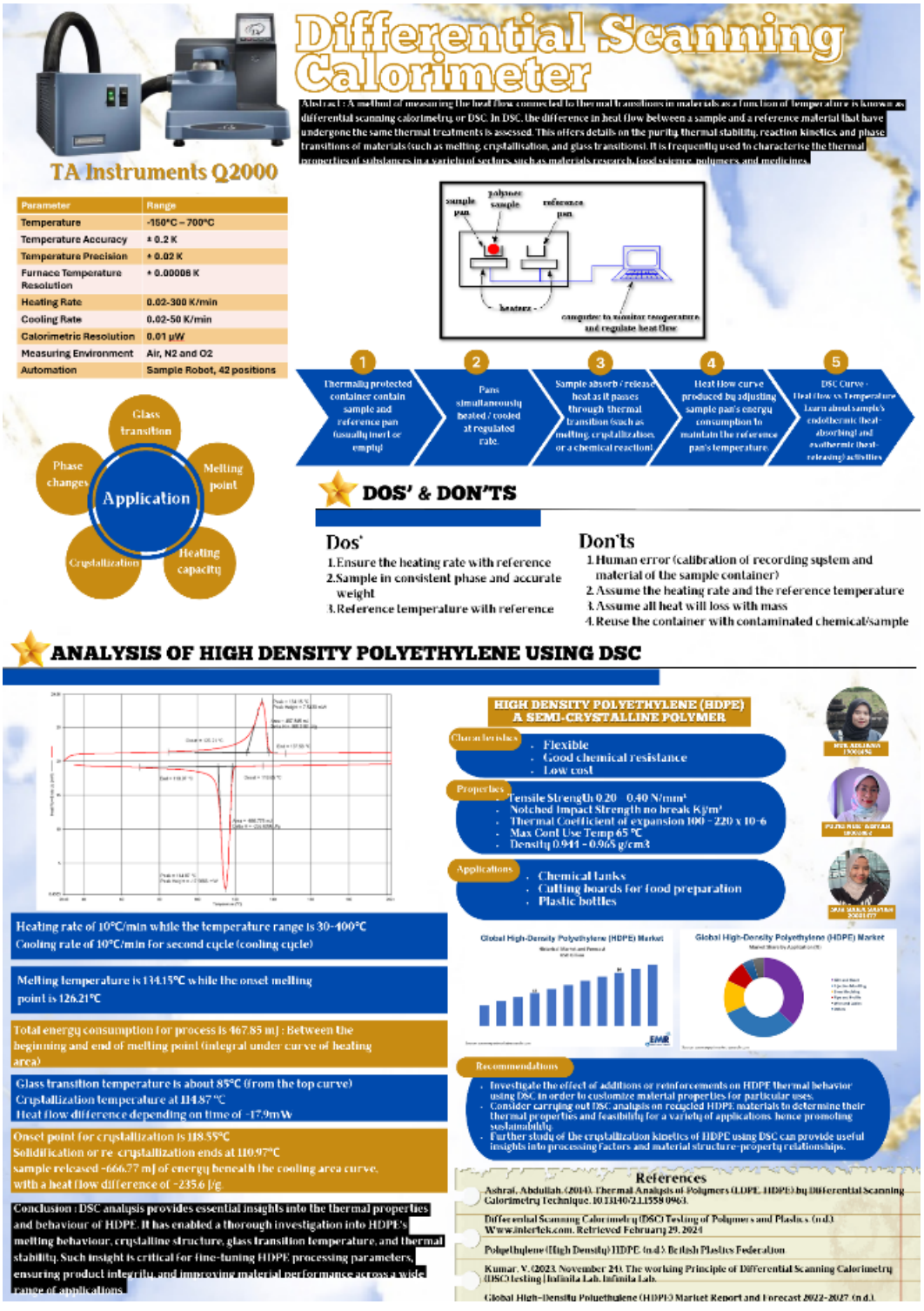


Figure 5 Poster of study of CAL application in MSCE

References

Issah, I., Baalongbuoro, V., & Oware, S.A. (2023). The impact of laboratory practical activities on Students' academic performance at Queen of peace senior high school in the nadowli-kaleo dstrict of the upprt west region of Ghana. I*nternational Journal of Scientific Research and Management (ISRM), 11*(3), 2727-2739. Doi:10.18535/ijsrm/v11i03.3l2.

Kusmawan, U. (2022). A virtual lab as a vehicle for active learning through distance education. *International Journal of Research in STEM Education (IJRSE)*, *4*(2), 18-38.

Theresa, C., Pauline, L., & Kate, D. (2022). An evaluation of the effects of Pre-laboratory activities on student engagement in a higher education computer engineering module. All Ireland *Journal of Teaching and Learning in Higher Education (AISHE-J), 14*(2), 1-34.

Wei, H., Treagust, D.F., Mocerino, M., Vishnumolakala, V.R., Zadnik, M.G., Lucey, A.D., & Lindsay, E.D. (2020). Design and validation of an instrument to measure student's interactions and satisfaction in undergraduate chemistry laboratory classes. *Research in Science Education, 10*(6), 1-17.

Enhancing Comprehension of the First Law of Thermodynamics through A Hands-On Hot Air Balloon Project

Mior Azman Said*, Nursyarizal Mohd Nor, Abdelrahman Khedir Mohamed Gasmelseed
Universiti Teknologi PETRONAS, Malaysia
*miorazman@utp.edu.my

Introduction

The first law of thermodynamics is fundamental in engineering and physics, but students often struggle with its abstract nature. Traditional lecture-based approaches may not effectively foster deep understanding and practical application (Mulop et al., 2012). This study explores the effectiveness of a hands-on, project-based learning activity involving the construction of a hot air balloon to enhance student comprehension of the First Law of Thermodynamics. The project provided a tangible, engaging context to explore principles of heat transfer, energy conservation, and system design.

Objectives

The primary objective was to determine if a project-based learning approach using a hot air balloon design challenge could significantly improve student understanding and application of the first law of thermodynamics compared to traditional teaching methods. Secondary objectives included assessing students' teamwork skills and problem-solving abilities within the project context.

Methodology

A class of 35 students enrolled in thermodynamics participated in the study. The students were divided into teams of 7 and tasked with designing and constructing a hot air balloon system capable of sustained inflation using a limited set of materials (basin, mineral water bottle, tape, aluminum foil, cloth, balloon, and hot water). The project was divided into three phases: Design (25 minutes), Operation (20 minutes), and Sharing (10 minutes). Students were provided a detailed design brief outlining constraints and design considerations. The duration of balloon inflation determined the success of the project. Post-activity was administered to gather student feedback on the learning activity's effectiveness and evaluate their level of understanding.

Results

The survey results revealed a good response to the hot air balloon activity, as they mentioned that greater understanding was achieved by constructing the right insulation strategy. The winning team sustained inflation for more than 10 minutes, highlighting the successful application of thermodynamic principles.

A summary of the survey results can be shown in Table 1, which shows the effectiveness of the hot air balloon project activity.

Table 1 Summary of survey results

Category	Key Findings	Analysis
Activity Effectiveness	Overwhelmingly positive response (79.3% would like similar activities). Many noted improved understanding of the First Law of Thermodynamics.	Demonstrates the hot air balloon activity's success in engaging students and enhancing their comprehension of key thermodynamic concepts.
Learning Outcomes	Students learned practical application of thermodynamics (e.g., insulation strategies), teamwork, and real-world problem-solving.	Students successfully applied thermodynamic principles, as evidenced by the winning team's prolonged inflation time.
Winning Team Performance	The winning team sustained inflation for over 10 minutes.	This highlights a successful application of the learned thermodynamic principles, specifically insulation, to achieve a significant outcome (sustained inflation).
Areas for Improvement	Some suggestions for more complex activities and possibly refreshments were noted.	While mostly positive, minor adjustments could further enhance the learning experience.

Conclusion

The hot air balloon project proved an effective pedagogical tool for enhancing students' understanding and application of the First Law of Thermodynamics. The hands-on, problem-solving approach fostered active learning, improved engagement, and provided a practical context for understanding complex concepts. The positive student feedback supports integrating similar project-based activities into thermodynamics curricula. Further research could explore the long-term retention of knowledge gained through this approach.

Acknowledgement

The authors wish to express gratitude to the Centre of Sustainable Resource for Intelligent Efficient Mobility (CSRIEM) for the funding of this TLIF conference participation.

References

Mulop, N., Yusof, K. M., & Tasir, Z. (2012). A Review on Enhancing the Teaching and Learning of Thermodynamics. *Procedia - Social and Behavioral Sciences, 56,* 703–712.

Enhancing Student Engagement through Collaborative Learning Tools in Blended Learning Environments

Suriana Ismail*[1], Husna Sarirah Husin[2], Norhatta Mohd[1]
[1]Universiti Kuala Lumpur- Malaysian Institute of Information Technology, Malaysia
[2]Taylor's University, Malaysia
*suriana@unikl.edu.my

Introduction

Collaborative learning has become an effective pedagogical strategy in higher education, particularly in teaching programming language subjects. Recent studies emphasise the effectiveness of cooperative learning in enhancing students' understanding of programming languages. For instance, research by Kim et al. (2021) demonstrates that collaborative programming activities improve students' problem-solving skills and increase their engagement with course content. Similarly, Li et al. (2023) found that cooperative learning environments promote deeper conceptual understanding and knowledge retention among students in programming courses.

The concept of student engagement can be defined as the degree of students` involvement in the classroom either in the form of: (a) conduct and task behaviour (behavioural engagement); (b) attitudes, interests and values (emotional engagement); and (c) self-efficacy and motivational goals (cognitive engagement) (Fredricks et al., 2004). Laurillard (2012) claims that collaborative learning (learning through production) is a powerful type of learning because it engages both experiential learning (learning through experience) and social constructivism (learning through discussion).

The objective of this study is to examine the engagement of students in an online collaborative learning environment. By analysing survey data from male and female students, we seek to identify key areas where their experiences diverge and converge. This study aims to provide actionable insights to inform the design and implementation of more inclusive and effective Learning Management System (LMS) platforms. This study contributes to the broader discourse on educational technology by highlighting the importance of gender-sensitive approaches in digital learning environments.

Research Methodology

Participants
The participants of this study are undergraduates enrolled in a programming language course at UNIKL-MIIT. The sample includes a total of 61 students involved in the experiment.

Experiment Setting
The setting for the research:
Online class environment using MsTeam and Jamboard – survey evaluation and observation

Data Collection
Data collection was conducted online using Google Forms and observation. Participation was voluntary, and respondents were assured of the confidentiality and anonymity of their responses.

Results and Discussion

Results from the online survey show positive feedback from the participants in using collaborative learning tools such as Jamboard in learning programming language as depicted in Figure 1.

Based on observation of participants' engagement, evidence shows that the engagement happened during the online learning session using a collaborative learning tool. Figure 2 shows that participants are actively engaged and participate in the online learning environment.

Based on the results, this study has investigated and assessed the levels of student engagement within an online collaborative learning environment. Class session observation shows that online collaborative learning environments can significantly enhance student engagement compared to traditional methods. The interactive nature of these platforms encourages active participation, fosters peer learning, and promotes a more profound understanding of course material. The study identified various factors influencing student engagement, including the design of collaborative activities, the functionality of the online tools employed, and the facilitation of discussions by class instructors. Effective use of these elements correlates positively with higher levels of engagement among students.

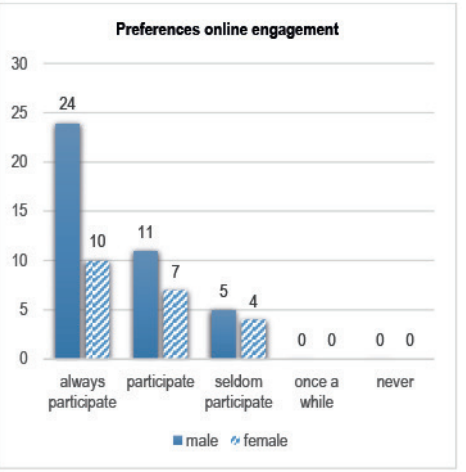


Figure 1 Student engagement comparison between genders on collaborative learning

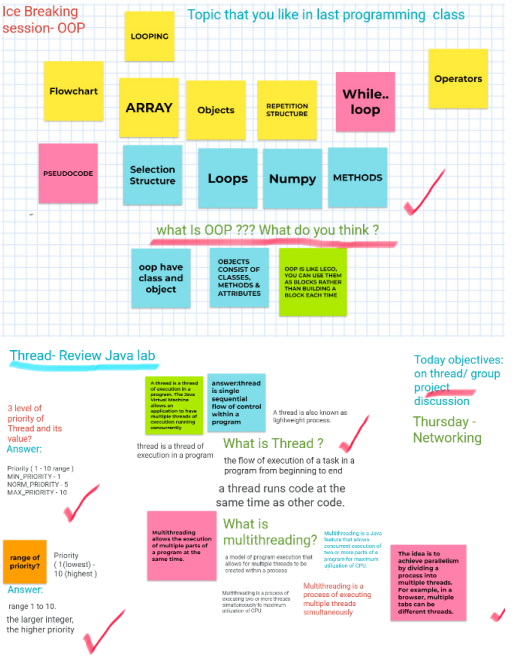


Figure 2 Student engagement input via Jamboard observation

Conclusion

Collaborative learning represents a valuable approach to teaching programming languages in higher education, offering significant benefits such as improved learning outcomes, soft skill development, and peer learning opportunities. However, challenges related to group dynamics, assessment, and technology integration require careful consideration. By adopting best practices and leveraging technological advancements, educators can create enriching collaborative learning environments that prepare students for the complexities of programming language subjects and future careers.

Acknowledgement

The authors acknowledge the Universiti Kuala Lumpur for funding the conference paper.

References

Google. (n.d.). Jamboard - Collaborative whiteboard for schools. Retrieved from https://workspace.google.com/products/jamboard/

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2020). NMC Horizon Report: 2020 Higher Education Edition. Educause. Retrieved from https://library.educause.edu/resources/2020/8/2020-nmc-horizon-report

Nicolson, M. (2021). Supporting remote learners with digital collaboration tools. *Journal of Online Learning Research, 7*(3), 289-304.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. Review of Educational Research, 74(1), 59-109.

Laurillard, D. (2012). Teaching as a design science: Building pedagogical patterns for learning and technology. *Routledge*.

Dai, H., & Bonk, C. J. (2022). Exploring the effectiveness of collaborative online learning activities in computer science education. *Computers & Education, 177*, 104378. doi:10.1016/j.compedu.2021.104378

Kim, Y., Lee, D., & Song, J. (2021). Impact of collaborative programming activities on students' learning outcomes and perceptions in a computer science course. *Journal of Computing in Higher Education, 33*(1), 148-167. doi:10.1007/s12528-020-09255-8

Understanding Market Efficiency: Mechanisms, Implications, and Challenges

Farhan Mirza*
Universiti Teknologi PETRONAS, Malaysia
*farhan_22009826@utp.edu.my

Introduction

Understanding market efficiency is fundamental in economics, with significant implications for investment strategies and regulatory policies. The Walrasian General Equilibrium Theory posits that asset prices reflect all available information, making it challenging for investors to achieve above-average returns consistently (Ball, 2009). However, market efficiency is not a binary concept, and factors such as market power and externalities can lead to market failures and inefficient outcomes (Martin & Nagel, 2022).

As educators, finding effective ways to help students grasp the complexities of market efficiency and its mechanisms is crucial. Traditional lecture-based teaching methods may fail to fully engage students and foster a deep understanding of these concepts. Innovative teaching practices, such as experiential learning simulations, can enhance students' comprehension by actively involving them in simulated market scenarios (Laverie et al., 2022).

This study aims to investigate the impact of innovative teaching methods on students' understanding of market efficiency. By comparing the effectiveness of traditional lectures and experiential learning simulations, the research provides insights into the most effective ways to teach market efficiency concepts and promote a better understanding of their real-world implications.

There are two objectives for the approach:

1. To improve the impact of innovative teaching methods on students' understanding of market efficiency concepts.
2. To develop critical thinking by highlighting the potential of innovative teaching practices to deepen students' grasp of complex economic principles and their real-world applications.

Literature Review

According to the Walrasian General Equilibrium Theory, when all markets in an economy clear simultaneously, the resulting allocation of goods and services is Pareto efficient (Borges, 2010). The literature classifies market efficiency as weak, semi-strong, and strong. Weak form efficiency suggests technical analysis is ineffective because prices reflect historical data (Lim & Brooks, 2011). Semi-strong form efficiency says prices adjust quickly to public information, making fundamental analysis useless (McGoun, 1990). According to solid-form efficiency, prices reflect all public and private information, raising ethical concerns about insider trading (Rossi, 2015).

Misallocated resources cause market failure, which reduces social welfare due to monopoly power and information asymmetries (Ai, 2022). Since prices reflect intrinsic values, efficient markets optimise resource allocation and minimise market failure. Market efficiency relies on information dissemination, arbitrage, and behaviour. For efficiency, information flow must be fast and accurate, and corporate governance improves this (Armstrong et al., 2010). Arbitrageurs reduce price gaps, improving market efficiency (Subramanian & Overby, 2017). However, behavioural finance shows that psychological biases can cause market inefficiencies (Sharma et al., 2021).

Innovative teaching practices like experiential learning simulations have enhanced students' understanding of complex economic concepts. By actively engaging students in simulated market scenarios, these methods can deepen their grasp of market efficiency mechanisms and their real-world applications (Farrell, 2020). The literature suggests innovative teaching practices can be more effective than traditional lecture-based methods in promoting student engagement and learning outcomes.

Methodology

This study employs a quasi-experimental design to investigate the impact of innovative teaching methods on students' understanding of market efficiency. The sample comprises 36 students enrolled in an introductory economics course: a control group receiving traditional lectures on market efficiency concepts and an experimental group participating in experiential learning simulations.

Pre- and post-intervention assessments were conducted to measure changes in student knowledge. The assessments consisted of multiple-choice questions and short-answer prompts designed to evaluate students' understanding of market efficiency mechanisms, including information dissemination, arbitrage, and behavioral factors. Thirty-six independent raters graded the assessments to ensure reliability.

The data was analysed using repeated-measures ANOVA to determine the effectiveness of the teaching methods in improving students' understanding of market efficiency. The analysis compared the pre- and post-intervention scores of the two groups, controlling for potentially confounding variables such as prior knowledge and demographic characteristics.

Findings

The findings of this study indicate that the experiential learning group demonstrated significantly more improvements in understanding market efficiency than the traditional lecture group. The repeated-measures ANOVA revealed a significant interaction effect between teaching method and time (pre- vs post-intervention), $F(1, 98) = 15.72$, $p < .001$, $\eta^2p = .14$. Post-hoc analyses showed that while both groups improved their understanding of market efficiency from pre- to post-intervention, the experiential learning group's improvement was significantly more significant than the traditional lecture group's improvement, $t(98) = 3.96$, $p < .001$, $d = 0.80$. The experiential learning group's mean score increased from 65.2 (SD = 10.4) to 82.1 (SD = 9.7), while the traditional lecture group's mean score increased from 64.8 (SD = 11.2) to 72.5 (SD = 10.5).

These findings suggest that experiential learning simulations are more effective than traditional lectures in enhancing students' understanding of market efficiency concepts. By actively engaging students in simulated market scenarios, the experiential learning approach promotes a deeper grasp of the mechanisms underlying market efficiency and their real-world implications.

Discussion

This study adds to the literature on innovative economics teaching practices. The findings show that experiential learning simulations can help students understand complex concepts like market efficiency. This method allows students to understand market efficiency mechanisms and their real-world implications by actively engaging them in simulated market scenarios.

The study stresses promoting market efficiency and addressing market failure factors. Understanding market efficiency and market failures helps policymakers create more effective regulations and interventions to boost economic growth and social welfare.

Conclusion

This study shows that experiential learning simulations improve market efficiency understanding more than lectures. This innovative teaching method helps students understand market efficiency mechanisms and their real-world implications by actively engaging them in simulated market scenarios. The findings add to the literature on innovative economics teaching practices and have important implications for educators and policymakers. They suggest that experiential learning simulations can boost economics students' learning. According to the study, policymakers should promote market efficiency and address market failure factors. Experiential learning simulations should be studied for their long-term effects on students' understanding of market efficiency and real-world application. They should also be tested for their ability to teach other complex economic concepts and foster interdisciplinary learning and problem-solving.

Acknowledgment

This research was conducted in class, and no funding was received.

References

Ai, H. (2022). Market Failures in Takeovers. In *Protecting Societal Interests in Corporate Takeovers: A Comparative Analysis of the Regulatory Framework in the UK, Germany and China* (pp. 15-33): Springer.

Armstrong, C. S., Guay, W. R., & Weber, J. P. (2010). The role of information and financial reporting in corporate governance and debt contracting. *Journal of accounting and economics, 50*(2-3), 179-234.

Ball, R. (2009). The global financial crisis and the efficient market hypothesis: what have we learned? *Journal of Applied Corporate Finance, 21*(4), 8-16.

Borges, M. R. (2010). Efficient market hypothesis in European stock markets. *The European Journal of Finance, 16*(7), 711-726.
Farrell, C. (2020). Do international marketing simulations provide an authentic assessment of learning? A student perspective. *The International Journal of Management Education, 18*(1), 100362.

Laverie, D. A., Hass, A., & Mitchell, C. (2022). Experiential learning: A study of simulations as a pedagogical tool. *Marketing Education Review, 32*(1), 3-17.

Lim, K. P., & Brooks, R. (2011). The evolution of stock market efficiency over time: A survey of the empirical literature. *Journal of economic surveys, 25*(1), 69-108.

Martin, I. W., & Nagel, S. (2022). Market efficiency in the age of big data. *Journal of financial economics, 145*(1), 154-177.

McGoun, E. G. (1990). A re-evaluation of market efficiency measurement. *Critical Perspectives on Accounting, 1*(3), 263-274.

Rossi, M. (2015). The efficient market hypothesis and calendar anomalies: a literature review. *International Journal of Managerial and Financial Accounting, 7*(3-4), 285-296.

Sharma, D., Misra, V., & Pathak, J. (2021). Emergence of behavioural finance: A study on behavioural biases during investment decision-making. *International Journal of Economics and Business Research, 21*(2), 223-234.

Subramanian, H., & Overby, E. (2017). Electronic Commerce, spatial arbitrage, and market efficiency. *Information systems research, 28*(1), 97-116.

Application of Active Learning in Engineering Design-Based Module

Revathi Raviadaran*
Universiti Teknologi PETRONAS, Malaysia.
*revathi.raviadaran@utp.edu.my

Introduction

In the contemporary educational environment, instructors engage Generation Z individuals born between the mid-to-late 1990s and the early 2010s (Garikapati et al., 2016). This cohort is characterised as digital natives, having been immersed in the internet, smartphones, and social media from a young age, which has cultivated advanced digital literacy and multitasking abilities.

The rapid technological advancements associated with globalisation have rendered devices such as smartphones, laptops, and tablets essential to daily life. These tools facilitate instantaneous access to vast repositories of information, thereby enhancing the accessibility of learning resources. However, the ubiquitous use of these devices has also transformed communication patterns and social interactions, often resulting in diminished face-to-face engagement between students and educators (Verduyn et al., 2021). This shift affects students' communication skills, leading to more passive participation during lectures and less interactive classroom dynamics.

Active learning has been recognised as an effective pedagogical strategy that fosters deeper student engagement (Mduwile & Goswami, 2024). This approach requires students to actively participate in their learning process through critical thinking, discussion, investigation, and creation. Within the classroom, students apply skills, address complex problems, make decisions, and articulate their understanding through written and verbal communication. Providing timely feedback from instructors and peers is crucial to this learning process (Theobald et al., 2020). Empirical studies have demonstrated that integrating active learning strategies into university curricula significantly enhances student learning outcomes (Freeman et al., 2014).

This study aimed to evaluate the impact of active learning on student communication and academic performance. A comparative analysis was conducted to assess student performance on a class test in a Year 4 Chemical Engineering module, Industrial Effluent Engineering, at Universiti Teknologi PETRONAS (UTP), contrasting outcomes with and without the implementation of active learning techniques.

Related Work/Literature Review

Several studies have explored using active learning as a pedagogical strategy for engineering students. One study at Universidad Politécnica de Madrid examined the motivation of Master's students in Aerospace Engineering across two subjects employing different educational techniques (López-Fernández et al., 2019). One subject utilised a traditional,

teacher-centred approach, while the other incorporated active learning methods, such as Project-Based Learning. In this latter approach, students engaged in the preliminary design of a space mission, beginning with mission requirements and integrating subsystems of a microsatellite using demonstration satellites. The findings confirmed the positive impact of active learning methods on the motivation of aerospace engineering students.

Mirkouei et al. (2016) investigated how to enhance student learning in manufacturing engineering through real-time process evaluations. They developed a pedagogical framework consisting of four steps: defining learning outcomes, creating instructional resources, designing active learning resources, and establishing a summative assessment mechanism. This framework was applied to develop a participatory pedagogy for manufacturing courses, utilising computer numerical control of operations and real-time monitoring, visualisation, and data analysis of machine energy consumption. The framework was successfully implemented in upper-level undergraduate and graduate manufacturing engineering courses at Oregon State University and the University of California, Berkeley, demonstrating its effectiveness in supporting learning module development in manufacturing education.

In a study by Cho et al. (2021), the flipped classroom model was implemented for mechanical engineering students to assess the pedagogical advantages of active learning from a self-determination theory perspective. The study compared students' academic performance in the flipped classroom with those in a traditional lecture format. Results indicated that students in the flipped classroom performed better and preferred the new model, highlighting the potential of the flipped classroom to foster an autonomy-supportive learning environment and enhance educational experiences in traditional mechanical engineering courses.

Deshpande and Salman (2016) examined the impact of the active learning strategy 'think-pair-share' on developing students' problem-solving skills in engineering mathematics. The sample comprised 66 students divided into two groups: an experimental group of 33 students utilising the 'think-pair-share' strategy and a control group of 33 students following traditional instructional methods. The results demonstrated that the 'think-pair-share'strategy positively influenced the development of problem-solving skills compared to conventional methods.

The studies discussed above underscore the potential of active learning strategies to enhance student engagement in the classroom, ultimately leading to improved academic performance.

Research Methodology

This study assessed student performance through two tests, each comprising engineering design questions worth 50 marks. These assessments were administered at different points during the semester. Before Test 1, six weeks of lectures were conducted without implementing active learning strategies. In contrast, Test 2 was administered after six more weeks of lectures incorporating active learning techniques. The analysis focused on student involvement in class and performance in the two tests. The involvement was quantified based on the submission of class activities that utilised active learning strategies, while performance was evaluated based on the marks obtained in the tests.

This study involved 17 Year 4 Chemical Engineering students enrolled in the Industrial Effluent Engineering module. All participants were Malaysian nationals aged 22 to 23, comprising 10 males and seven females.

Active learning strategies implemented during the lecture are provided below:

1. Focussed listing
   2 min to list points related to the topic, discuss with the neighbor, share with class, discussion.

2. Opening question
   Pose questions related to the topic, 1 minute individually, 1-minute discussion with the neighbour, share with the class, and discussion.

3. Think-pair share
   Answer questions individually, compare with the neighbour, share with the class, and discuss.

4. Two-minute paper
   Summarise the topic in 2 minutes, discuss it with the neighbour, share it with the class, and discuss it.

Result and Discussions

Based on Figure 1, student submissions of class activities showed notable improvement over the six-week lecture period. Participation levels reached ≥90% from the third week onward, with 100% submission recorded in both the third and fifth weeks. This increase indicates enhanced student engagement during lectures incorporating various active learning strategies. There was a marked rise in student interest and motivation, as evidenced by increased face-to-face discussions with peers and direct interactive participation during class sessions.

Figure 2 illustrates student performance on Test 1 and Test 2. Test 1 was administered following six weeks of traditional lecture sessions, while Test 2 followed six weeks of lectures that integrated active learning strategies. Results revealed that performance in Test 2 surpassed that of Test 1, with 29% of students achieving grades of A or A- in Test 1,

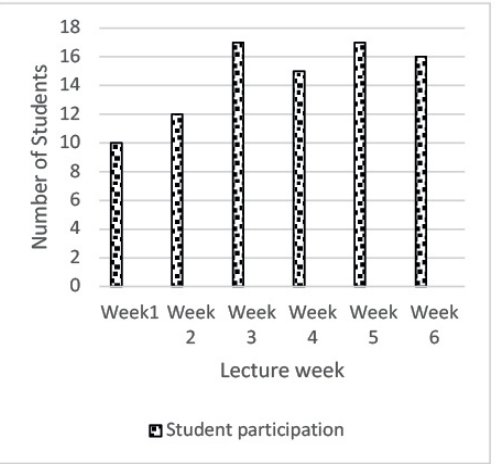


Figure 1 Students' submission of class activities incorporating active learning strategies

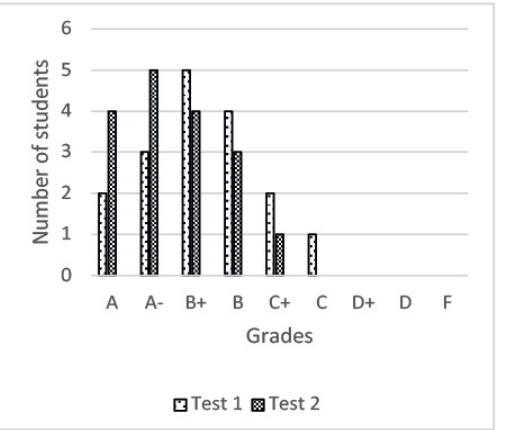


Figure 2 Grades of students for Test 1 and Test 2

compared to 53% in Test 2. This reflects a 24% increase in students earning these higher grades. While three students scored C+ and C in Test 1, only one scored C+ in Test 2. The average grade for Test 1 was B+, whereas the average for Test 2 improved to A-. These findings suggest that participation in class activities utilising active learning strategies influenced their test performance. Techniques such as 'Focused Listing' helped students recap previous lessons, while the 'Opening Question' strategy introduced the day's topic

and engaged students' interest. The 'think-pair-share' strategy encouraged collaborative problem-solving, enhancing understanding. Additionally, the 'Two-Minute Paper' at the end of class prompted students to reflect on the day's material, aiding retention. These active learning strategies fostered motivation, participation, and comprehension, facilitating active discussion and communication within the classroom, which contributed to improved test performance for a design-based engineering module.

Conclusion

This study demonstrated that incorporating active learning strategies into class activities during lectures is highly effective, particularly for Generation Z students pursuing their first degree in higher education. These strategies successfully engage students in the teaching and learning process, motivating them to acquire the necessary knowledge and skills to complete their assessments. Enhanced communication and engagement during lectures contributed to improved performance on tests. Lectures incorporating active learning strategies such as 'Focused Listing,' 'Opening Questions,' 'Think-Pair-Share', and 'Two-Minute Papers' led to improved performance on the test, where the average grades improved from B+ in Test 1 to A- in Test 2. Active learning strategies in design-based engineering modules boost student motivation, participation, and academic performance. The study concludes that using active learning in engineering education creates a more engaging, student-centred environment that meets the needs of Generation Z learners.

Acknowledgement

The author acknowledges the support provided by the Department of Chemical Engineering and the Centre for Excellence in Teaching and Learning (CeTaL) of UTP for this work.

References

Cho, H. J., Zhao, K., Lee, C. R., Runshe, D., & Krousgrill, C. (2021). Active learning through the flipped classroom in mechanical engineering: improving students' perception of learning and performance. *International Journal of STEM Education*, *8*, 1-13.

Deshpande, A., & Salman, B. (2016). Think-pair-share: Application of an active learning technique in engineering and construction management classes. *Associate Schools of Construction, 52nd Annual Conference Proceedings,* New York, NY,

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the national academy of sciences*, *111*(23), 8410-8415.

Garikapati, V. M., Pendyala, R. M., Morris, E. A., Mokhtarian, P. L., & McDonald, N. (2016). Activity patterns, time use, and travel of millennials: A generation in transition? *Transport Reviews*, *36*(5), 558-584.

López-Fernández, D., Ezquerro, J. M., Rodríguez, J., Porter, J., & Lapuerta, V. (2019). Motivational impact of active learning methods in aerospace engineering students. *Acta Astronautica*, *165*, 344-354.

Mduwile, P., & Goswami, D. (2024). Enhancing student engagement: Effective strategies for active learning in secondary school classrooms. *MULTIPLE: Journal of Global and Multidisciplinary*, *2*(5), 1746-1757.

Mirkouei, A., Bhinge, R., McCoy, C., Haapala, K. R., & Dornfeld, D. A. (2016). A pedagogical module framework to improve scaffolded active learning in manufacturing engineering education. *Procedia Manufacturing*, *5*, 1128-1142.

Theobald, E. J., Hill, M. J., Tran, E., ... Littlefield, C. E., & Lowe, A. (2020). Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences, 117*(12), 6476–6483.

Verduyn, P., Schulte-Strathaus, J. C., Kross, E., & Hülsheger, U. R. (2021). When do smartphones displace face-to-face interactions, and what should we do about it? *Computers in Human Behavior*, *114*, 106550.

Impact of Teaching Styles on Undergraduates' Motivation and Acceptance Towards Learning Laboratory-Based Subjects

Amni Haslinda Alpandi*[1], Hazlina Husin[2]
[1]Universiti Teknologi Malaysia, Malaysia
[2]Universiti Teknologi PETRONAS, Malaysia
*amnihaslinda@utm.my

Introduction

Concept of Motivation

Filgona et al. (2020) identify three primary sources of motivation,

1. Course-related factors: This includes elements such as the syllabus, teaching materials, teaching methods, and learning activities.
2. Instructor-related factors involve aspects of the instructor's behavior, personality, and pedagogical approach or teaching style.
3. Group-related factors: This encompasses the dynamics within the learner group.

According to Filgona et al. (2020) there are two types of motivation: intrinsic and extrinsic. Intrinsic motivation is a powerful internal drive that compels students to immerse themselves in academic pursuits. This motivation springs from a genuine interest in learning and a love for the educational journey (Chow & Yong, 2013). Such learners relish the challenge of honing their abilities, eagerly pursuing knowledge without the lure of external rewards (Chow & Yong, 2013). Those who strive for a deep understanding and mastery of scientific concepts and skills exemplify this intrinsic motivation (Cavallo et al., 2003). Extrinsic motivation originates from external factors that encourage individuals to perform tasks to achieve specific outcomes. This can take the form of rewards, social approval, or recognition. Harmer (2015) notes that extrinsic motivation may stem from various influences, such as the desire for financial gain, the need to pass exams, or aspirations for future success. Marsh (2000) further emphasises that it involves external stimuli from specific responses. According to Ryan and Deci (2000), learners are driven by the expectation of benefits beyond the learning. Chow and Yong (2013) highlight that this motivation leads students to engage in academic tasks for external reasons. Additionally, Benabou and Tirole (2003) suggest that extrinsic motivation enhances effort and performance, with rewards acting as positive reinforcers for desired behaviours.

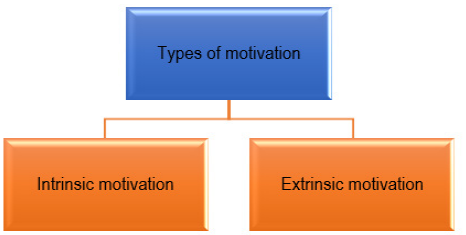


Figure 1 Types of motivation

Teaching Style

Every educator brings a unique approach to teaching. As traditional methods evolve with the rise of differentiated instruction, many teachers are increasingly tailoring their

strategies to meet the diverse learning needs of their students. Exploring various teaching styles began in the early 20th century, driven by extensive research into different learning methods. Recognising that students have distinct learning preferences highlighted the need for diverse teaching approaches to engage all learners effectively. Different teaching styles are crucial because they align with the varied ways students absorb information. The selection of a particular style can be influenced by factors such as the school's mission, classroom demographics, the educator's educational philosophy, and the subject matter being taught. Adapting teaching methods can revitalise the classroom environment and prevent monotony. Each student may have individual learning preferences. For example, visual aids can be beneficial for kinesthetic or visual learners. To ensure that all students grasp new concepts, teachers should explore alternative explanations rather than merely repeating previous instructions. Engaging students in suggesting new methods can also be valuable. Incorporating visual tools like maps, graphs, or concrete examples can further assist students struggling to understand new concepts (Seven, 2019).

Learning Laboratory-Based Subjects in Higher Education Institute

Laboratory-based subjects serve as prerequisites for core courses in engineering programs. The traditional approach to laboratory sessions is essential for undergraduates, as it helps bridge the gap between theoretical concepts and practical applications in engineering (Isa et al., 2022). Engaging in hands-on training deepens students' understanding and aligns with the curriculum requirements set by professional accreditation bodies, such as the Engineering Accreditation Council Malaysia (2009). This integration of practical experience is crucial for fostering students' motivation and acceptance of laboratory-based learning, highlighting the significant influence of teaching styles on their educational journey.

Research Methodology

This qualitative research utilised open-ended questionnaires to collect primary data from Petroleum Engineering students at Universiti Teknologi Malaysia via the Online Teaching Evaluation and Student Experience (ePPPK) platform at the end of the semester. The questionnaires were distributed to students enrolled in the laboratory course over two semesters, from October to February 2024 and from March to July 2024, yielding 77 responses. The collected data were analysed using a coding approach using Atlas.ti software. The details of the respondents involved in this study are shown in Table 1.

This current study has focused on undergraduates' motivation and acceptance towards learning laboratory-based subjects, which is impacted by the teaching styles of the lecturer. This study aligns with the Integrated Course Design (Fink, 2013), starting with the intended outcomes, prioritising what learners will gain from experience rather than what

Table 1 Details of the respondents involved in this study

Year/Semester	Course Code	Course Name	Total Number of Enrolment	Total Number of Respondent
2023/2024-1	SETP1711-01	Fluid Mechanics Laboratory	40	34
2023/2024-1	SETP1711-02	Fluid Mechanics Laboratory	26	17
2023/2024-2	SETP2731-02	Thermodynamics & Mechanics of Material Laboratory	28	26

the teacher will cover. In this way, Integrated Course Design exemplifies a student-centred learning approach. Figure 2 illustrates the research design for this study.

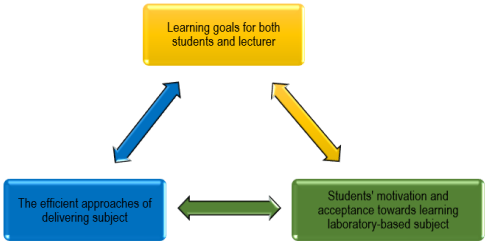


Figure 2 The current research design in this study

Result and Discussions

This qualitative analysis was conducted among 77 respondents with open-ended questionnaires. This study identified and categorised 51 responses into 11 distinct codes. Figure 3 presents the themes of each code based on the keywords provided by respondents. A semantic network was then developed, grouping these into five overarching themes: positive learning environment, instructor's dynamic personality, engaging teaching methods, uniqueness of laboratory-based subjects, and challenges related to the course.

Based on Figure 3, the results indicate that the learning environment and the instructor's approach are the most influential factors in motivating students to engage with laboratory-based subjects. Creating a positive, stress-free atmosphere where students feel appreciated allows them to focus more on learning rather than on external pressures. This reinforces the importance of teaching styles that prioritise student well-being alongside academic content. Instructors play a pivotal role in shaping students' perceptions of laboratory work. A dynamic and professional instructor can be a role model, helping students see the real-world value of laboratory-based subjects. The ability to inspire and teach through practical

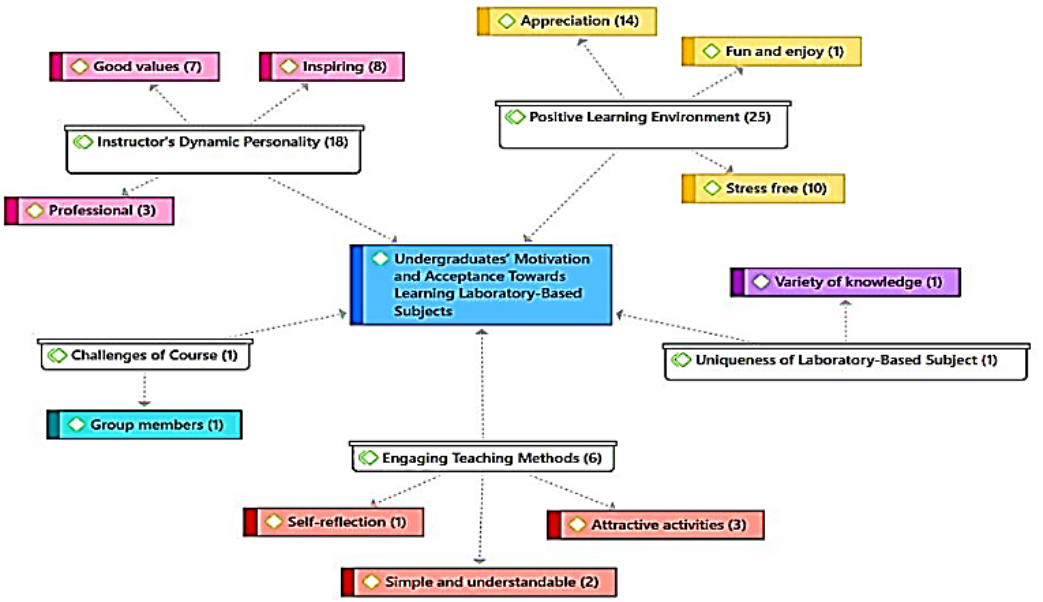


Figure 3 The semantic network of undergraduates' motivation and acceptance towards learning laboratory-based subjects

demonstrations ensures that students remain engaged and motivated to learn. Teaching methods that are interactive, fun, and aligned with student needs are critical in this respect. According to Ali et al. (2024), instructional or teaching methods can influence students' interest and academic achievement through motivational processes. Furthermore, the unique characteristics of laboratory-based subjects offer a rich learning experience for students. However, challenges related to group work and the complexity of the tasks must be addressed to ensure that all students can participate fully and benefit from the learning process.

Conclusion

This study underscores the need for a holistic approach to teaching laboratory-based subjects. The learning environment, the instructor's style, and engaging teaching methods play crucial roles in motivating students and fostering their acceptance of the subject matter.

Acknowledgement

The authors would like to acknowledge the Yayasan Universiti Teknologi Petronas (YUTP) grant (015LC0-383) for providing financial support related to the conference. The authors also thank the Petroleum Engineering students of Universiti Teknologi Malaysia for their cooperation in completing the online teaching evaluation and student experience forms.

References

Ali, N. B., Abd Rahim, S., Ismail, S., & Alpandi, A. H. (2024). Exploring students' reactions and preferences in learning CTU552 Philosophy and Current Issues: A qualitative study, *Asian Journal of Research in Education and Social Sciences*, *6*(1), 75-88.

Benabou, R., & Tirole, J. (2003). Intrinsic and extrinsic motivation, *The review of Economic Studies*, *70*(3), 489-520.

Cavallo, A. M., Rozman, M., Blinkenstaff, J., & Walker, N. (2003). Students' learning approaches, reasoning abilities, motivational goals, and epistemological beliefs in differing college science courses, *Journal of College Science Teaching*, *33*(3), 18-23.

Chow, S. J., & Yong, B. C. S. (2013). Secondary school students' motivation and achievement in combined science, *Online Submission*, *3*(4), 213-228.

Filgona, J., Sakiyo, J., Gwany, D. M., & Okoronka, A. U. (2020). Motivation in learning, *Asian Journal of Education and Social Studies*, *10*(4), 16–37.

Fink, L. D. (2013). *Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses*. New Jersey: John Wiley & Sons.

Harmer, J. (2015). *The Practice of English Language Teaching*. New York: Pearson.

Isa, I. S., Abdullah, H., Kasim, N. M., Ismail, N. A., & Faiza, Z. (2022). Open distance learning simulation-based virtual laboratory experiences during COVID-19 pandemic. *International Journal of Electrical and Computer Engineering*, *12*(4), 4042–4053.

Marsh, C. J. (2000). *Handbook for Beginning Teachers*. Sydney: Pearson Education Australia.
Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic Motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54-67.

Seven, M. A. (2019). Innovation in Language Learning and Teaching. *Innovation in Language Learning and Teaching*, *8*(8), 62–71.

Technology-Enhanced Learning: A Pathway to Education 4.0

Nasir Shafiq*
Universiti Teknologi PETRONAS, Malaysia
*nasirshafiq@utp.edu.my

Introduction

Currently, technology is developing rapidly, new trends are evolving, and the aspirations of all stakeholders are changing. Technology-enhanced learning (TEL) facilitates novel techniques and tools. However, it is not the only source to inculcate students' understanding. The principal aim of this paper is to perform a critical review of the role of TEL in improving the quality of the teaching and learning process to nurture future talents to position themselves in the changing world. Blended learning is a method developed on the constructivist learning theory, situational awareness, and learning & education dissemination theory that integrates the traditional teaching model with full utilisation of modern information and communication technologies (ICT) to achieve the best portfolio of various teaching elements in the teaching process. The development of the Moodle system followed the philosophy of the constructivism theory, which proved to be an effective tool for teaching management globally. It is based on self-instructed modules that offer a user-friendly learning environment. Education 4.0 has brought the blueprint for education in the era of Industry 4.0. It integrates humanist ideas with the digital world.

Related Theories for TEL in the ICT Environment

At the beginning of the 21st century, ICT were embedded in the teaching and learning environment, creating TEL. In the earlier phase of TEL, e-learning models helped learners develop competence and conceptual understanding; since then, online education has constantly brought new methodologies into place.

TEL: From e-Learning to Artificial Intelligence (AI)

The evolution to Web 2.0 can be regarded as a breakthrough that blurs the developers' and users' boundaries. It allowed internet users to create specific content without holding specialised (ICT) competencies. The development of Web 2.0 can be regarded as the milestone of TEL, which appeared in Education 2, where some information channels, resource sharing, video services, discussion forums, chats, instant messaging, and email appeared in the teaching and learning process. The evolution of Web 2.0 to Web 3.0 brought artificial intelligence (AI) into the ICT environment, making a real difference to leapfrog in TEL. With the development of AI, computers can perceive information like a human brain, which enables them to create faster and more accurate results (Gerstein, 2014; Sarowski, 2017). In short, Web 3.0 is based on an integrated Web environment, which allows machines to understand and catalog data in a human-like manner, i.e., computer programs could perform certain activities without the presence of a human being (Sarowski, 2017). The education experts termed this era Education 3.0, where

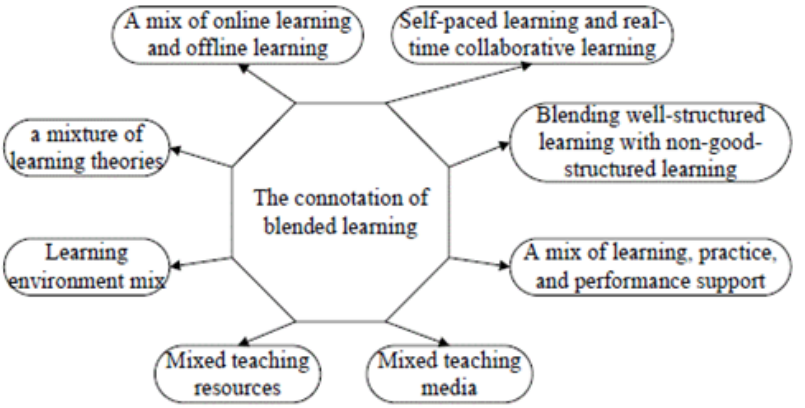


Figure 1 Octagonal chart of blended learning connotations.

teachers and learners are embarked on a unique, personalised, and self-determined journey. Experts foresee that education could change work contexts during

Blended Learning

Blended learning is a method developed on the constructivist learning theory, situational awareness, and learning and education dissemination theory that integrates the traditional teaching model with full utilisation of modern ICT to achieve the best portfolio of various teaching elements in the teaching process (Selwyn, 2007). Blended learning integrates teaching resources, teaching media, learning environment, learning theories, learning forms and methods, well-structured and unstructured learning practices, and performance support. Figure 1 illustrates an octagonal chart of blended learning connotations (Selwyn, 2007; Sarowski, 2017). In the blended learning process, the lecturer's responsibility is to teach and organise students, where students are involved in self-disciplined learning.

Acknowledgement

The author would like to extend the acknowledgement to the Universiti Teknologi PETRONAS for providing the facilities and support for this research.

References

Xinwen B. & Xiaodan S. (2019). On the effects of computer-assisted teaching on learning results based on blended learning method *International Journal of Emerging Technologies in Learning, 14*(1), pp: 58-69.

Gerstein, J. (2014). Moving from education 1.0 through education 2.0 towards education 3.0. *Boise State University ScholarWorks.* https://scholarworks.boisestate.edu/

Sarowski, Ł. (2017). From Web 1.0 To Web 4.0 – The Evolution of forms communication spaces in the global network. *Social Dissertations, 11*(1), 32-39. https://doi.org/10.29316/Rs.2017.4

Selwyn, N. (2007). The use of computer technology in university teaching and learning: A critical perspective. *Journal of Computer Assisted Learning. 3*(2), 83-94.

Kanban Method for Agile Teaming and Project Management in MVP-Engineering Team Project I

Lila Iznita Izhar*[1], Kishore Bingi[1], Azlan Ahmad[2], Oh Pei Ching[2], Nursyarizal M Nor[2], Huzein Hawari Fahmi[2]
[1] Universiti Teknologi PETRONAS, Malaysia
[2] Universiti Malaysia Perlis, Malaysia
*lila.izhar@utp.edu.my

Introduction

This paper examines the application of the Kanban method in a course offered to Year 2 Semester 2 students, known as the Engineering Team Project (ETP). By utilising Kanban's core principles—visualising work, limiting work-in-progress, and fostering continuous improvement—the study explores its impact on team dynamics, project management, and student learning outcomes in this course.

Managing complex projects is crucial in the rapidly evolving landscape of engineering and technology. As industries increasingly adopt Agile methodologies to streamline workflows and enhance collaboration, the education sector must adapt to equip future engineers with the skills necessary to thrive in these environments. The Kanban method, a key Agile framework, offers a visual and flexible approach to project management that emphasises continuous improvement and efficient workflow management.

In engineering education, project-based courses are integral to preparing students for real-world challenges. These courses often require students to work in teams to design, develop, and implement technical solutions under real-world constraints, mirroring professional engineering practices. However, managing such projects can be challenging, particularly when coordinating tasks across multidisciplinary teams with varying expertise and work styles.

In Universiti Teknologi PETRONAS (UTP), a Minimum Viable Product (MVP) has been established for the existing single major engineering disciplines, aimed at piloting the 'Build the Worlds' project-based learning (PBL) concept adapted from the Integrated Engineering Foundation curriculum. The Engineering Team Project (ETP) (MFB2061 & MFB2012) has been designated the MVP for the May 2024 semester, with enhancements in delivery and pedagogy.

This paper explores the implementation of the Kanban method in the MVP-ETP I course, examining how its principles can be leveraged to enhance team collaboration, project management, and learning outcomes. By visualising tasks, limiting work-in-progress (WIP), and focusing on continuous feedback and improvement, Kanban provides a structured yet adaptable framework that can be tailored to the unique demands of engineering projects. Through a detailed case study, this paper investigates the effectiveness of Kanban in improving team dynamics, streamlining project workflows, and ultimately delivering successful project outcomes within the academic setting.

The findings of this study aim to provide valuable insights for educators and institutions seeking to integrate Agile methodologies into their curricula, ensuring that engineering students are well-prepared to meet the demands of contemporary engineering practices.

Related Work / Literature Review

Adopting Agile methodologies in project management has seen significant growth across various industries, particularly in engineering and software development. Agile's iterative approach, which emphasises flexibility, customer collaboration, and responsiveness to change, contrasts with traditional, linear project management models such as Waterfall. Among the various Agile frameworks, the Kanban method stands out for its simplicity, visual nature, and focus on continuous improvement (Anderson, 2010).

Kanban, developed initially as part of the Toyota Production System, has evolved into a widely used tool for managing workflows in manufacturing and knowledge work environments (Liker, 2004). In project management, Kanban's visual task board and principles of limiting WIP allow teams to optimise their workflow by identifying bottlenecks and reducing inefficiencies (Corona & Pani, 2013). Studies have shown that Kanban can increase productivity, improve communication, and improve team collaboration in project settings (Ahmad et al., 2013).

Integrating Agile methodologies into educational settings, particularly in engineering and computer science courses, has gained traction over the past decade. Research indicates that Agile practices like Scrum and Kanban can enhance student engagement, collaboration, and understanding of project management principles (Paasivaara et al., 2017). Agile methods encourage active learning, where students are not just passive recipients of information but actively participate in the learning process through iterative project development and continuous feedback (Kropp et al., 2014).

While Agile methodologies like Scrum have been more extensively studied in educational contexts, there is a growing body of literature exploring the use of Kanban in engineering education. Research suggests that Kanban's emphasis on visualising tasks and managing workflow can help students better understand project management concepts and improve their ability to work collaboratively in teams (Mahnič & Hovelja, 2012). Kanban's flexibility also makes it suitable for diverse project environments, allowing students to adapt the framework to the specific needs of their projects (Hiranabe, 2008).

In one study, Mahnič (2010) demonstrated that using Kanban in a software engineering course helped students manage their workload more effectively, leading to improved project outcomes and a deeper understanding of Agile practices. Similarly, another study by Kuhrmann et al. (2016) highlighted the potential of Kanban to enhance team performance and communication in multidisciplinary engineering projects.

Despite its benefits, implementing Kanban in educational settings is not without challenges. Some researchers point out that students may initially struggle with the self-management and discipline required by Kanban, particularly in limiting WIP and adhering to continuous improvement practices (Patel et al., 2016). Additionally, the effectiveness of Kanban depends on proper guidance and support from instructors, as well as the student's ability to adapt to a more autonomous learning environment (Moniruzzaman & Hossain, 2013).

The literature underscores the potential of the Kanban method to enhance project management and teaming in engineering education. However, it also highlights the need for further research into its application across different engineering disciplines and project types. By exploring these gaps, educators can better understand how to leverage Kanban to prepare students for the complexities of modern engineering practices.

Research Methodology

Students are given a 2-hour session on Agile teaming and Project Management. The fundamental approach of Agile methodology was conveyed to the students. Kanban Method/Board, an Agile project management framework, was taught to the students. Kanban Board is used primarily for software development but applies to any complex, innovative scope of work. It can help visualise your work, limit progress, and maximise efficiency/flow. It is a structured yet flexible way to organise and manage work, encouraging teams to deliver high-quality products or services in short, iterative cycles. The students received a fast-track introduction and hands-on experience with the Kanban Board, including a brief overview of its features, functionality, and a touch of Scrum, as shown in Figure 1. Group supervisors acted as facilitators to enhance students' understanding and closely guided the students throughout the session.

Hands-On: Kanban Board Implementation

The flow of the hands-on activity using the Kanban Board method is as follows:

Step 1: On a piece of large paper, students are instructed to create four columns for four stages of prototype development, namely backlog, doing, sprint, and done.

Step 2: Based on the case study that was given in their design thinking sessions done in the early phase of the course, they need to list the tasks involved in completing their prototype in the backlog column. The backlog items must be arranged according to importance, dependencies, and project goals. Time given: 10 minutes.

Step 3: They need to move some of the tasks at the top rank of the backlog column to the doing column. They can limit the number of functions in the doing stage at one time. Time given: 5 minutes.

Step 4: Pick a task at a time to be moved to the sprint stage from the tasks underdoing. The task chosen can be a task that can be completed quickly. Usually, this will be a 1- to 2-week-long type of task. However, for this hands-on activity, only 10 minutes are given.

Step 5: Once a task from the sprint column is completed, it is moved to the done column. They must agree on the criteria determining when a backlog item or task is considered complete.

Step 6: Following the steps the instructor facilitated, students had first-hand experience in implementing the Kanban Board for project management. They were also asked to do a 5-minute stand-up time where they discussed the following items.

1. What did I do yesterday to help the team meet the sprint goal? (They were asked to prepare for the hands-on activity.)
2. What will I do today to help the team meet the sprint goal?
3. What impediment(s) do I see that prevent me or the team from meeting the sprint goal?

Step 7: Finally, the students were asked to reflect on their hands-on experience implementing the Kanban Board. For this reflection, each student was required to create 4 to 6 post-its based on the following requirements.

1. At least 2 "+" post-its: Things that you did well, things someone else did well, things that were good.
2. At least 2 "Δ" ("Improve" / "Even Better If") post-its: Things you (as a team, as individuals) could have done better.

The students shared their post-its, discussed their reflections within the team, and identified one area for improvement (kaizen) to focus on as a team next time.

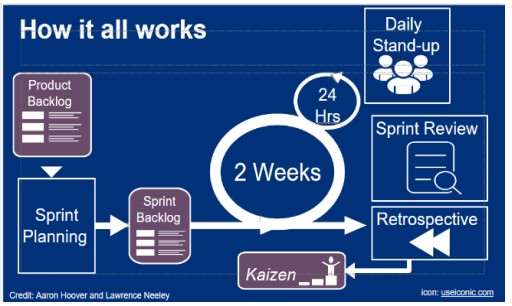


Figure 1 The framework of the Kanban Board method with a touch of Scrum for Agile project management

Result and Discussions

The students successfully used the Kanban Board Method to manage their prototype development for the case study. Figure 2 shows the Kanban Board created by one of the ETP groups. It was observed that, despite the limited time, they could list many tasks and complete most of them, thanks to the Kanban Board framework.

Based on the reflections shared by the students after the hands-on activity (Figure 3), it is evident that they have gained valuable insights into what is required to manage and complete their projects successfully. Most agreed that communication between team members, as well as with supervisors, is of utmost importance. The students also realised they needed to put more time, focus, and effort into their project development. Not only that, but some of them also realised that they needed to be more creative and innovative. This activity has led them to appreciate the design thinking techniques, including the Agile framework taught earlier in the course by respective ETP coordinators and facilitated by respective group supervisors. They were also found to be more eager and motivated to embark on their prototype development journey.

Their reflections on using the Kanban Board for managing their project proposal development



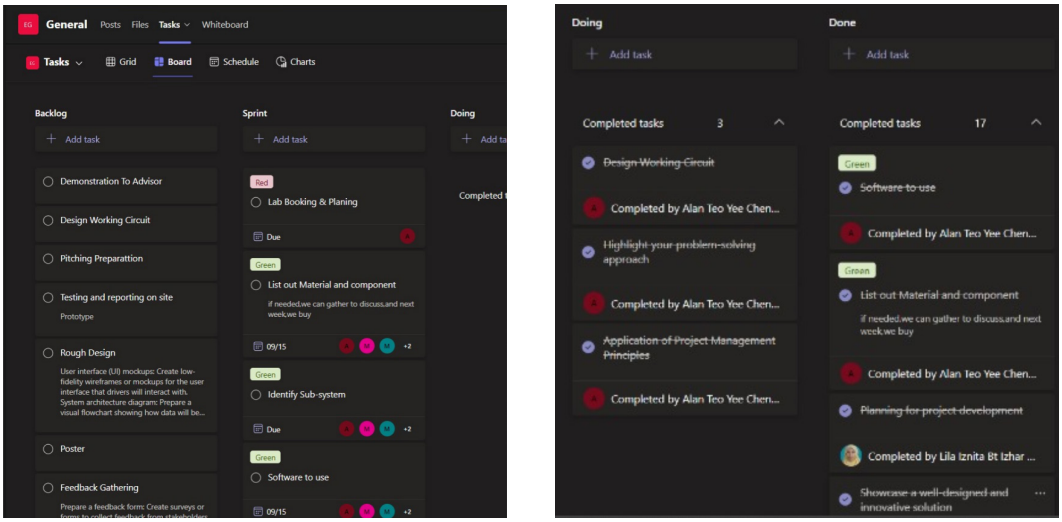
Figure 2 A sample of the Scrum board created by Group 10



Figure 3 The Post-it sharing during team reflection

were acquired through Microsoft Whiteboard application as shown in Figure 4 and 5..

Once they had learned and experienced the Agile project management framework through the Kanban Board method, they were required to implement this in managing their actual ETP Project. The students could choose any application, including Microsoft Planner, for this purpose. Their ETP supervisors monitored the implementation closely. This also becomes a platform for supervisors to monitor work



(a) (b)

Figure 4 The Kanban Board was created by Group 10 to manage their project proposal development during (a) the early phase and (b) after completion (partial view)

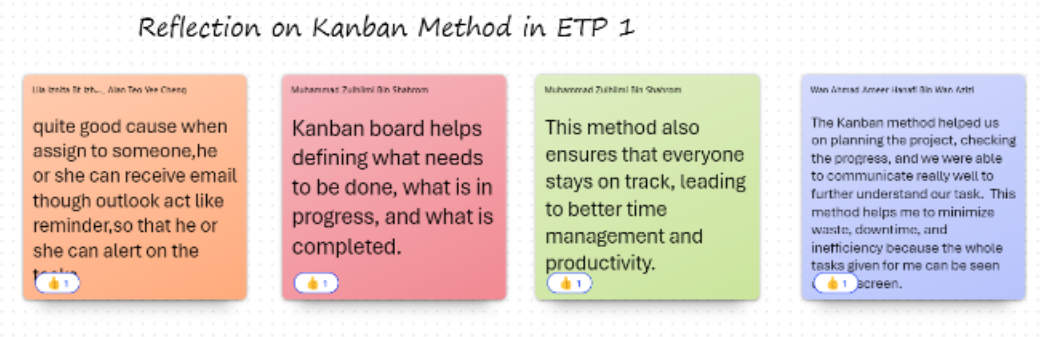


Figure 5 Students' reflections on their experience implementing the Kanban Board method for managing their project proposal development

progress and students' performances closely. Any issues or risk factors should be identified quickly and addressed before they escalate.

However, for ETP 1, the deliverable for their final assessment was to prepare a Project Proposal in a 4-minute-long video format within two weeks. This will allow each team to showcase their ideas creatively and dynamically. Essential details and the assessment rubric were shared with the students.

Conclusion

Implementing the Kanban Method for project proposal development was a successful and insightful experience for the students. Despite time constraints, they effectively utilised the Kanban Board framework to organise and complete many tasks, demonstrating the practical benefits of this project management approach.

The hands-on activities and subsequent reflections revealed that the students gained valuable skills in task management and developed a deeper appreciation for effective communication, creative problem-solving, and the design-thinking techniques taught earlier in the course. Their newfound motivation and eagerness to apply these skills to their ETP projects highlight the impact of experiential learning.

As the students transition to managing their actual ETP Project in ETP 2, the Kanban Method will continue to serve as a critical tool, supported by applications like Microsoft Planner and closely monitored by their supervisors. This ongoing implementation will provide a structured platform for supervisors to track progress, identify potential issues early, and ensure that the projects remain on course. The final assessment of ETP 1, involving the submission of a Project Proposal in a dynamic video format, offers an opportunity for the students to present ideas creatively, further reinforcing the skills and knowledge gained throughout this process. Thanks to the Kanban Method, with limited time, the students still completed their deliverables very well.

The findings suggest that Kanban streamlines complex engineering tasks and equips students with practical Agile skills, making it a valuable addition to project-based engineering education.

Acknowledgement

The authors wish to thank UTP for the support in attending the Executive Education Programme at SUTD, Singapore. The authors also would like to acknowledge UTP and Alliance University, India, for supporting this work under the International Collaborative Research Fund (ICRF), grant number 015ME0-379.

References

Ahmad, M. O., Markkula, J., & Oivo, M. (2013). Kanban in software development: A systematic literature review. *Software Engineering: Challenges and Solutions, 14*(1), 11-24.

Anderson, D. J. (2010). *Kanban: Successful Evolutionary Change For Your Technology Business*. Washington: Blue Hole Press.

Corona, E., & Pani, F. E. (2013). A review of lean-Kanban approaches in the software industry. *WSEAS Transactions on Information Science and Applications, 10*(1), 1-13.

Hiranabe, K. (2008). Kanban applied to software development: From agile to lean. *InfoQ Software Architects Newsletter,* January 14.

Kropp, M., Meier, A., & Biddle, R. (2014). Teaching agile collaboration skills in the classroom. *Proceedings of the 2014 Conference on Innovation and Technology in Computer Science Education,* 49-54.

Kuhrmann, M., Münch, J., & Diebold, P. (2016). Software process improvement: A systematic mapping study on the state of the practice. *Journal of Software: Evolution and Process, 28*(9), 767-799.

Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from The World's Greatest Manufacturer.* New York: McGraw-Hill.

Mahnič, V. (2010). Teaching Scrum through team-project work: Students' perceptions and teacher's observations, *International Journal of Engineering Education, 26*(1), 96-110.

Mahnič, V., & Hovelja, T. (2012). On using Kanban in software engineering education, *Proceedings of the 15th International Conference on Interactive Collaborative Learning*, 1-6.

Moniruzzaman, A. B. M., & Hossain, S. A. (2013). Comparative study on Agile software development methodologies, *International Journal of Computer Applications, 46*(4), 8-14.

Paasivaara, M., Lassenius, C., & Heikkilä, V. T. (2017). Teaching students Scrum using LEGO blocks*, Proceedings of the 38th International Conference on Software Engineering Companion*, 549-558.

Patel, A., Kairiya, R., & Patel, K. (2016). Agile project management methodologies: A comparative analysis, *Journal of Information Technology & Software Engineering, 6*(2), 1-7.

Integration of Augmented Reality (AR) for Enhancing Safety Protocols through Standard Operating Procedures (SOP), Job Safety Analysis (JSA), and Hazard Identification and Risk Assessment and Risk Control (HIRARC)

Jazmin Zulkifli[1], Mohammed Nizam Abdul Aziz[2], Dzulkarnain Zaini[2*]
[1]Universiti Teknologi Mara Kampus, Malaysia
[2]Universiti Teknologi PETRONAS, Malaysia
[*]dzulkarnain.zaini@utp.edu.my

Introduction

Traditional engineering practices rely on manual procedures, physical equipment, and two-dimensional data representations. These methods suffer from limitations in interactivity, accessibility, and efficiency. Additionally, the reliance on outdated safety protocols when using engineering equipment contributes to frequent accidents and operational inefficiencies. These challenges highlight the need for more innovative and interactive engineering education and practice approaches.

Augmented Reality (AR) technology presents a potential solution by overlaying digital information onto the physical world, creating an immersive and interactive user experience. AR allows users to visualise complex data and equipment in three dimensions, making understanding intricate systems and processes more manageable. This technology has rapidly evolved, offering promising opportunities to enhance various fields, including engineering education and research.

By seamlessly integrating virtual and physical realms, AR enables users to interact with digital content in real-time, leading to improved understanding and safety practices when using engineering equipment. This innovative approach not only enhances the learning experience for students but also ensures that engineers and technicians can operate equipment more safely and efficiently.

In modern engineering settings, there is a growing demand for innovative solutions that leverage augmented reality (AR) technology to enhance various procedures in using engineering equipment and handling the equipment cautiously. Furthermore, users, specifically students, often have difficulty understanding the usage of engineering equipment and its Standard Operating Procedures (SOPs), Job Safety Analysis (JSA), and Hazard Identification, Risk Assessment, and Risk Control (HIRARC). Therefore, creating AR systems that display physical engineering setups and interfaces can significantly ease users' challenges.

Literature Review

Researchers and educators recognise the potential of AR to streamline the use of engineering apparatus, visualise complex equipment, display SOPs, and enhance HIRARC. AR can improve engineering tasks' accuracy and efficiency by providing real-time, interactive guidance and information. AR Furthermore, AR can improve safety protocols by delivering immediate, context-aware safety information and alerts, thus reducing the likelihood of accidents and promoting safer working environments.

According to Li et al. (2017), engineering problems are generally modelled mathematically to represent physical phenomena across various fields, such as solid mechanics, heat transfer,

fluid dynamics, electrical engineering, and magnetism. Mathematical models can depict nearly all physical phenomena in diverse disciplines, including mechanical, biological, aerospace, and chemical engineering. These models use assumptions and axioms to describe the properties of physical systems. Techniques like numerical simulations allow for the approximation of solutions to these problems.

AR, which has been researched extensively over many years, can be integrated with human capabilities to enhance engineering analysis significantly. Technically, AR systems overlay computer-generated content onto the physical environment, thus improving a user's perception and understanding of their surroundings (Azuma, 1997). AR allows users to interact with virtual and real objects in their environment, facilitating the simultaneous assessment of multiple parameters and more effective problem analysis. A comprehensive AR system must include tracking, registration, and visualisation components (Li et al., 2017).

Li et al. (2017) also highlight that AR applications in engineering have evolved from desktop systems to mobile platforms, driven by the portability and accessibility of mobile devices. This transition enables engineers to access and interact with relevant information on-site, enhancing problem-solving capabilities. AR supplements traditional numerical simulation methods, such as the finite element method (FEM), offering an intuitive and scientific approach to practical problem analysis. Key applications of AR include real-time structural analysis, environmental simulation, and collaborative design processes.

The integration of AR in engineering education has been widely studied. AR tools have been found to improve spatial visualisation skills, which are crucial for engineering students. Studies, such as those by Álvarez-Marín and Velazquez-Iturbide (2021), indicate that AR applications can boost student motivation and engagement by offering interactive and immersive learning experiences. Like Mejías and Andújar (2012), pilot studies demonstrate AR's effectiveness in remote labs and practical classes by making complex electrical engineering concepts more accessible.

In addition, AR technology blends virtual elements with the real world, allowing simultaneous interaction with both. AR has improved student engagement, understanding, and motivation in engineering education. For example, Criollo-C et al. (2021) developed an AR mobile application (NetAR) to complement traditional engineering education. Their study found that AR applications could enhance learning by providing interactive 3D elements for students to manipulate, thereby deepening their understanding of complex concepts.

In practical engineering, AR applications range from maintenance and assembly tasks to design and simulation. Palmarini et al. (2018) systematically reviewed AR applications in maintenance, highlighting the technology's potential to increase accuracy and reduce downtime. Similarly, Blanco-Novoa et al. (2018) evaluated AR systems in industrial settings, demonstrating significant improvements in operational efficiency and worker safety. Furthermore, AR improves the visualisation of engineering designs by enabling engineers to overlay digital models onto physical objects, identifying design flaws, and validating design choices (Álvarez-Marín & Velazquez-Iturbide, 2021). This is particularly valuable in fields like civil and mechanical engineering, where accurate spatial understanding is essential.

Despite its benefits, AR in engineering faces several challenges. High development costs and the need for specialised hardware are significant barriers to widespread adoption. Technical challenges, such as tracking and registration errors, issues like lag, limited field of view, and high computational power requirements, can impede the seamless integration of AR into engineering workflows. Moreover, user interfaces and interaction techniques must be intuitive and user-friendly. Studies by Criollo-C

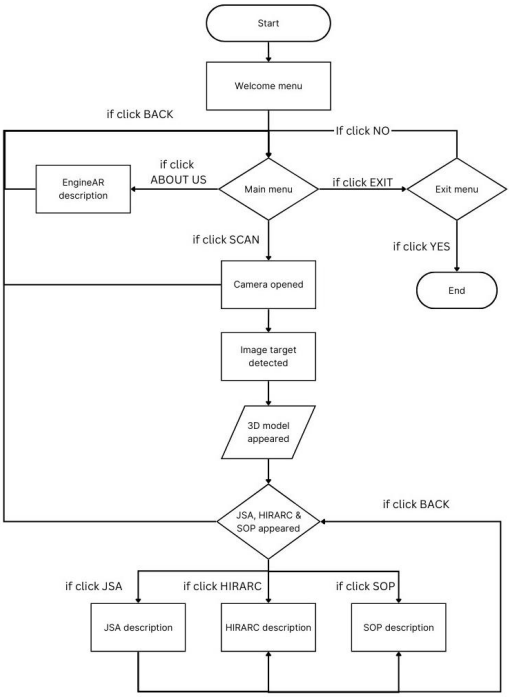


Figure 1 Flowchart of EngineAR

et al. (2021) have shown that mobile device size and AR interface complexity can affect learning outcomes and user satisfaction.

Nevertheless, the future of AR in engineering appears promising, with ongoing advancements. Integrating AR with other emerging technologies, such as artificial intelligence and the Internet of Things (IoT), could further enhance its capabilities. Continued research and development are crucial to overcoming current limitations and unlocking the full potential of AR in engineering. According to Criollo-C et al. (2021), developing more sophisticated AR devices, such as smart glasses with better resolution, more expansive fields of view, and enhanced computational capabilities, holds great promise. Additionally, creating AR applications tailored to specific engineering disciplines and educational levels can offer more targeted and compelling learning experiences, addressing the diverse needs of students and professionals in the engineering field.

In conclusion, AR holds significant potential to transform engineering education and practice through superior visualisation, enhanced training methodologies, and heightened operational efficiency. Despite existing challenges, continuous advancements in AR technology suggest a promising future for its deployment in the engineering sector. Ongoing research and innovation are essential to addressing current limitations and maximising the benefits of AR in engineering.

Research Methodology

Augmented Reality (AR) technology is revolutionising the interaction between the users and their engineering equipment. By overlaying digital information onto the real-

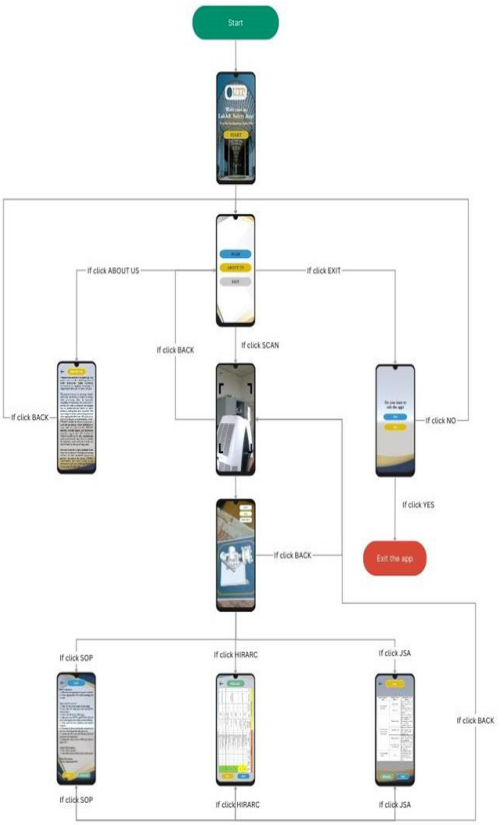


Figure 2 EngineAR UI information flowchart

world environment, AR provides instant access to Standard Operating Procedures (SOP), Job Safety Analysis (JSA), and Hazard Identification, Risk Assessment, and Risk Control (HIRARC) information. This technology improves operational efficiency and enhances safety and regulatory compliance. In this work, an AR prototype focuses on one of the identified issues regarding awareness and understanding of safety protocols. The designed prototype is called EngineAR, an AR application that visually presents safety protocols, including SOP, JSA, HIRARC, and 3D models of the engineering equipment engagingly and enjoyably. Figure 1 shows a flowchart regarding the user interface (UI) that was made to understand the app's workflow and function in detail.

Result and Discussions

EngineAR could revolutionise the interaction between the users and their engineering equipment. EngineAR provides instant access to SOP, JSA and HIRARC with UI information by overlaying digital information onto the real-world environment, as shown in Figure 2.

Conclusion

In conclusion, integrating AR for SOP, JSA, and HIRARC in the engineering sector holds great promise for enhancing safety education and practice. The project demonstrated that EngineAR could effectively bridge the gap between theory and practice, providing an easier learning environment and preparing users for real-world applications. As we move forward, expanding the use of AR in various engineering domains can lead to improved safety standards, reduced incidents, and a more knowledgeable and safety-conscious workforce.

Acknowledgement

The authors would like to thank Mr Khairul and Ms Hanum from the Centre for Excellence in Teaching and Learning (CETAL) for providing invaluable support and guidance to the success of this project. Their provision of resources, feedback, and expert advice has been instrumental in shaping the project and overcoming various challenges.

References

Álvarez-Marín, A., & Velazquez-Iturbide, J. A. (2021). Augmented reality and engineering education: A systematic review. I*EEE transactions on learning technologies, 14*(6), 817-831.

Azuma, R. T. (1997). A survey of augmented reality. *Presence: teleoperators & virtual environments, 6*(4), 355-385.

Blanco-Novoa, O., Fernandez-Carames, T. M., Fraga-Lamas, P., & Vilar-Montesinos, M. A. (2018). A practical evaluation of commercial industrial augmented reality systems in an industry 4.0 shipyard. *IEEE Access, 6*, 8201-8218.

Criollo-C, S., Abad-Vásquez, D., Martic-Nieto, M., Velásquez-G, F. A., Pérez-Medina, J. L., & Luján-Mora, S. (2021). Towards a new learning experience through a mobile application with augmented reality in engineering education. *Applied Sciences, 11*(11), 4921.

Li, W., Nee, A. Y., & Ong, S. K. (2017). A state-of-the-art review of augmented reality in engineering analysis and simulation. *Multimodal Technologies and Interaction, 1*(3), 17.

Mejías B.A., & Andújar M.J.M. (2012). A pilot study of the effectiveness of augmented reality to enhance the use of remote labs in electrical engineering education. *Journal of science education and technology, 21,* 540-557.

Palmarini, R., Erkoyuncu, J. A., Roy, R., & Torabmostaedi, H. (2018). A systematic review of augmented reality applications in maintenance. *Robotics and Computer-Integrated Manufacturing, 49*, 215-228.

Transformative Teaching: A Design Thinking Approach to Co-Creating Knowledge in the Classroom

Amjad Shamim*
Universiti Teknologi PETRONAS, Malaysia.
*amjad.shamim@utp.edu.my

Introduction

In today's dynamic educational landscape, fostering active student engagement remains a critical challenge. The increasing prevalence of technology has contributed to reduced student involvement in traditional lecture-based teaching (Bates, 2019). Recognizing this issue, the classroom environment was reimagined as a space for collaborative knowledge creation. Grounded in the principles of co-creation and service-dominant logic (Vargo & Lusch, 2016; Shamim, Ghazali & Albinsson, 2017), this transformative teaching initiative incorporates design thinking to empower students as active co-creators of their learning experience.

In student-centred learning, the acknowledgement that "one size does not fit all" is essential. Different students and classes require varying teaching and learning approaches. To design an effective learning environment, an understanding of the students is necessary — creating learner personas to inform the design of class activities that align with the unique needs of each group. This understanding facilitates a learning experience that maximizes engagement and fosters a deeper connection to the material.

Using design thinking as a foundation, the focus was placed on fostering student-to-student collaboration for shared learning. The classroom was transformed into a dynamic space where knowledge was actively co-created in groups.

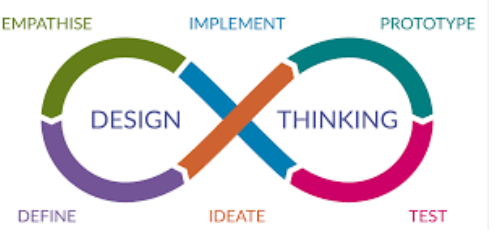


Figure 1 Design thinking framework *(adapted from Liedtka & Ogilvie, 2011)*

The design thinking-based co-creation of the knowledge model comprises several key intervention strategies.

Leadership through the GLoW Concept

Students often hesitated to take the initiative in responding to queries, instead waiting for others to lead. To address this, I introduced the Group Leader of the Week (GLoW) concept, assigning students rotational leadership roles. This initiative fostered a sense of responsibility in the assigned GLoW, ensuring they took the initiative, coordinated tasks with their peers for that week, and shared their progress in class. Each groupgroup's GLoW was encouraged to present and share their group's ideas with the class, facilitating group-to-group knowledge exchange. By rotating the GLoW role weekly, every member had the opportunity to lead, take initiative, and actively participate in collaborative learning.

Cooperative Learning and Real-world Application

Rather than relying solely on traditional lecture-based teaching, group-based activities centred on a selected case study or scenario were encouraged. The assigned GLoW further delegated roles to group members, ensuring that each member actively participated in reading, understanding, and sharing knowledge.

This approach enhanced cooperative learning by enabling students to apply theoretical knowledge to practical scenarios (Slavin, 2015). Through continuous ideation sessions, students became co-designers of solutions, fostering active participation and shared accountability within the group.

Tech-in-C Approach

Students were encouraged to adopt the Technology in Classroom (Tech-in-C) approach to ideate and engage in discussions. They provided various tools and opportunities to foster engagement and monitor student progress. Some of the Tech-in-C tools used are:

Padlet: Padlet was consistently used in the classroom for sharing group activities. This platform facilitated the collaborative sharing of assignments and ideas. Students were encouraged to create a unique brand name for their group, starting with an alphabet. The name needed to have meaning and include a vision and mission statement. Students acted as their group's Board of Directors (BoD) in this activity.

Slido.com: To encourage everyone to ask questions, I used Slido.com, where students could ask questions anonymously. Since their identities were not revealed, even those who typically did not ask questions in class began participating and engaging in discussions.

Mentimeter: The Think, Pair, Share (TPS) approach helped students recall previous lectures, share ideas with their peers, and present them to the class using Mentimeter. This tool fostered idea generation, lecture recall and allowed all learning to be displayed on a shared screen for everyone to review.

Socrative: To measure knowledge through competition-based quizzes. This increased student engagement, as students were motivated to complete the assessment in groups, striving to be the top performers.

Kahoot: For continuous assessment, Kahoot was frequently used, which kept students active, engaged, and happy while also measuring their learning.

Learning Management System (LMS) – Ulearn Forum: The Ulearn Forum was a valuable tool where students were encouraged to post questions, and their peers were asked to provide answers. Subsequent students built upon the answers, creating further discussions. This approach enhanced knowledge sharing and collaboration.

Outcomes: Cognitive, Affective, and Psychomotor

The impact of this design thinking-driven approach was visible across different areas:

Cognitive: Students actively recalled and applied the concepts during discussions and assessments. It was about remembering facts and engaging with and using the material in real-time scenarios (Bloom, 1956).

Affective: Students built a stronger sense of responsibility and collaboration through leadership roles and inclusive tools. This sense of ownership and teamwork helped them connect more deeply with their peers and the learning process (Krathwohl et al., 1964).

Psychomotor: Students showed increased creativity and confidence, mainly when presenting their ideas and participating in

interactive exercises. It was rewarding to see how their creativity flourished as they actively shaped the class activities (Armstrong, 1970).

Reflections and Continuous Improvement

This teaching model evolved through continuous feedback and adaptive strategies to meet student needs. The outcome was a co-creative learning ecosystem encouraging intrinsic motivation, meaningful engagement, and collaborative knowledge construction.

Conclusion

This student-centred design thinking approach to teaching underscores the power of empathy, ideation, and iteration in fostering an innovative learning environment. By actively encouraging students to shape their educational journey, this framework promotes engagement, innovation, and lifelong learning, offering a scalable model adaptable to diverse educational contexts.



Figure 2a Ideation Stage



Figure 2b Group sharing and feedback



Figure 2c Group sharing and feedback

References

Armstrong, R. J (1970). *Developing and Writing Behavioral Objectives*. Educational Innovators Press.

Bates, A. T. (2019). Building an effective earning environment. *Teaching in a Digital Age-Second Edition*.

Bloom, B. S. (1956). Taxonomy of Educational Objectives. New York: Longman.

Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). *Taxonomy of Educational Objectives: Affective Domain*. New York: Longman.

Liedtka, J., & Ogilvie, T. (2011). *Designing for Growth: A Design Thinking Tool Kit for Managers*. New York: Columbia Business School Publishing.

Slavin, R. E. (2022). Cooperative learning in elementary schools. In Brundrett, M., Beauchamp, G, … Wood, P., *Contemporary Issues in Primary Education* (pp. 102-111). London: Routledge.

Shamim, A., Ghazali, Z., & Albinsson, P. A. (2017). Construction and validation of customer value co-creation attitude scale. *Journal of Consumer Marketing*, *34*(7), 591-602.

Vargo, S. L., & Lusch, R. F. (2008). Service-dominant logic: continuing the evolution. *Journal of the Academy of Marketing Science*, *36*, 1-10.

Connecting the Dots: Engaging Students through Game-based Learning with a Blockchain Game

Mazeyanti M Ariffin*, Noreen Izza Arshad, Nazleeni Samiha Haron
Universiti Teknologi PETRONAS, Malaysia
*Email: Mazeyanti@utp.edu.my

Introduction

This study investigates the effectiveness of game-based learning in enhancing the understanding of blockchain technology among non-technical undergraduate students. Blockchain, a complex and technical subject, poses significant challenges in comprehension, particularly for those without a technical background. Conducted within the "Fundamentals of Information Systems" course in September 2024, this study involved 18 participants. A blockchain game, adapted from www.ngpf.org , was utilized to simplify and convey essential concepts. The study assessed student learning outcomes, engagement, and usability. Results indicated that all students demonstrated improved performance in their Test 1, increased their perceived educational value of the game, and showed strong motivation toward the content. Additionally, students effectively applied blockchain concepts in new contexts, as evidenced by their test responses. The study highlights the potential of game-based learning to bridge the gap between theoretical knowledge and practical application in technical subjects for non-technical learners. However, due to the limited sample size, further research is needed to confirm these findings. This study contributes to the growing body of evidence supporting game-based learning as an effective pedagogical approach for teaching complex technical topics to a broader audience.

Introduction

This study aims to report on the findings obtained from utilising game-based learning in teaching and learning. This study specifically discussed on the usage of game on the topic of block-chain.

Block Chain is one of current technology nowadays. Understanding this topic is value added to the students. However, Block Chain is a technical thing, and the concepts are challenging to non-technical students. Hence, this study was conducted to connect the dots between theory and practical on the concepts of Block Chain to non-technical students.

The aim of this study is to assess whether these students were engaged in the learning process and performed in the test and final exam. The study was conducted in Fundamental of Information Systems course in Sept 2024. There were 18 undergraduate students who participated in the study. Prior to the game selection, it was observed that Block Chain topic is one of the most challenging topics in the course among the students. This is due to its technical concepts. Hence, the game was selected based on its suitability to convey the fundamental technical concepts in a simple way. The Block Chain game is improvised from www.ngpf.org.

This study reports on the findings from implementing game-based learning in the teaching and learning process, with a specific focus on using a game to teach the concept of blockchain technology. Blockchain is an increasingly relevant technology in today's digital landscape, and gaining an understanding of this topic provides significant value to students. However, the technical nature of blockchain presents challenges, particularly for non-technical students. Therefore, this study was conducted to bridge the gap between theoretical knowledge and practical application of blockchain concepts for these students.

Related Work/Literature Review

Researchers have explored various ways to utilise games to enhance learning experience. Researchers has highlighted that a well-structured and constructively aligned game activity could demonstrated better educational outcomes and provide emotional satisfaction which indirectly reinforces the learning process (Mazeyanti, 2023). The utilization of games in class is defined as game-based learning (GBL) (Yusoff et al., 2018; Tokac, Novak, & Thompson, 2019). Research suggests that GBL has potential to be leveraged due to its positive impact.

Researchers suggest various ways to assess the effectiveness of GBL. An effective GBL strategy should not only address the learning aspects but also foster player engagement within an intuitive and user-friendly system. There are some prominent dimensions that being used widely in relation to the assessment of GBL such as learning, engagement, and usability. Therefore, in this study, the authors aimed to evaluate the effectiveness of GBL by examining the dimensions of learning, engagement, and usability (Yusoff et al., 2018).

Methodology

The primary objective of this study was to assess whether students engaged with the learning process and demonstrated improved performance in assessments, including tests. The study was carried out in the "Fundamentals of Information Systems" course in September 2024, involving seven undergraduate students. Prior observations indicated that blockchain was one of the most challenging topics in the course, primarily due to its technical complexity. The selected game, adapted from www.ngpf.org, was chosen for its ability to simplify and convey fundamental blockchain concepts in an accessible manner.

The selection of the game was made based on its suitability with the learning outcomes and how it constructively aligns with the learning outcomes. Table 1 shows the learning outcome for Block Chain module and its constructive alignment as well as the tools

Table 1 Learning outcomes, method of assessments and tools used

Learning outcomes		**Method of assessment**	**Aspects**	**Tool**
1	To explain the fundamental concepts of blockchain technology	Pre-class activity	Learning	Microsoft Forms
		Pre-test	Learning	Microsoft Forms
		Reflection questions	Learning	Padlet
		Post test	Engagement Usability	Microsoft Forms
		Test 1	Learning	
2	To apply fundamental concepts of blockchain technology in organisations	Test 1	Learning	



Figure 1 Pre-test



Figure 2 Post-test

Table 1 illustrates how the GBL were assessed. The study evaluated aspects of learning, engagement, and usability. Prior to the game activity, these students were requested to watch a short video on Block Chain Concept. The knowledge acquired from the video was assessed in the Pre-test session.

Result and Discussion

Learning Aspects

As mentioned earlier, students were requested to answer set of questions during the Pre-Test session. The aim of this activity is to assess the level of knowledge that they acquired from just watching the video. Figure 1 shows the folksonomy of the students answers. More than half of the class (53%, *n*=8) recalls the term 'Hash' as one of the important concepts in Block Chain. As compared to Post-Test, majority of the students recalls 'Consensus' as the one of the important concepts in Blockchain (as shown in Figure 2). Additionally, the concepts mentioned in Pre-test is limited to the basic concepts mentioned in Blockchain video. Thus, these students able to gauge the knowledge at the 'Remember & Understand' level in Bloom's Taxonomy from the Block Chain video. However, Figure 2 shows that students vocabularies and understanding towards Blockchain fundamental concepts has broaden and becomes richer which establishes to Level of 'Apply' in Bloom's Taxonomy. Hence, students should be able to establish their knowledge and apply to a different context.

Secondly, these students can demonstrate their understanding of the concepts of Block Chain after the deployment of the GBL session. Figure 3 shows a sample of students' responses. Figure 3 clearly shows that the students are able to explain the role of each concept richer and better.

It is worth to note that the questions in Test 1 were specifically designed to ensure these

students to relate block chain fundamental concepts in other settings. Students need to recall the concepts extracted from the game-play and adapt these concepts in a new setting and environment. Almost all students can demonstrate their understanding when answering the Test 1. These findings suggested that GBL has potential to be utilised to increase non-technical students' understanding towards topic which is too technical. However, the instructor decided to have formative reflection questions in between to help the students to relate with each concept that they have discovered. In this case, the instructor plays critical role to facilitate and guide the students in their learning experience. However, due to small sample size, strong conclusion can not be made from this study. More study needs to be done in near future on the utilisation Block Chain game to Fundamental to Information Systems course.

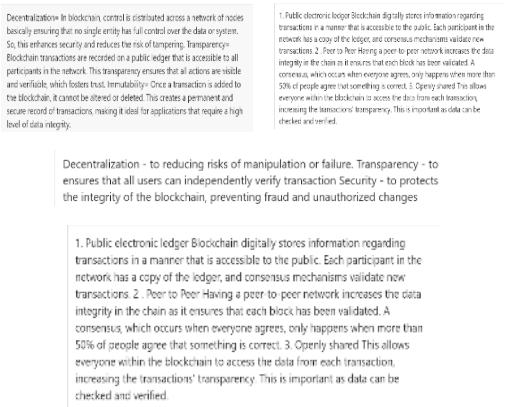


Figure 3 Sample of student responses

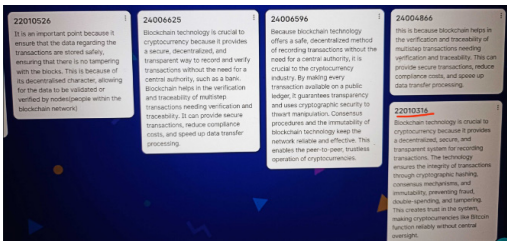


Figure 4 Sample of student reflections

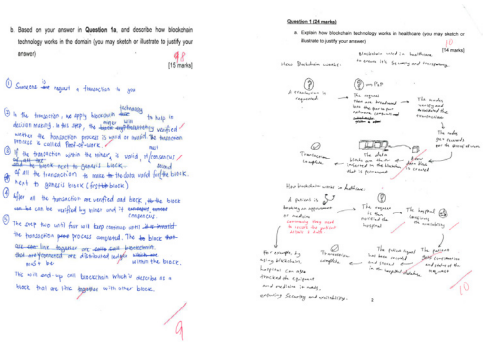


Figure 5 Sample of Test 1

Engagement/Usability Aspects

Figure 6 illustrates students' responses when asked on their perception towards playing game and their level of understanding in Block Chain. The findings suggested that all students perceived positively towards the experience with the game. This is one of the critical pieces of evidence that suggested students were fully engaged with the learning experience.

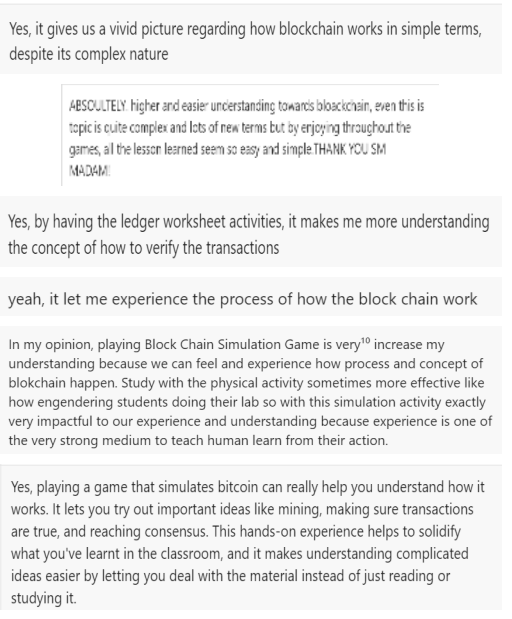


Figure 6 Sample of student responses

Additionally, students were also asked on what they enjoy the most during the GBL activity. The findings showed increased in perceived education value of the game itself, demonstrated strong motivation towards educational content. Positive comments and behaviours were also being observed during the game-play itself.

Conclusion

As a conclusion, this study demonstrated a positive impact on the utilisation of game-based learning when conveying technical concepts to non-technical students. The impacts could be seen on the student's motivation, behaviours and education performance. Nevertheless, more study needs to be conducted to larger sample to validate game-based learning effectiveness increasing the student's performance, engagement and motivation.

Given the small sample size, strong conclusions cannot be drawn from this study alone. Further research is necessary to explore the use of blockchain games in the "Fundamental of Information Systems" course on a larger scale. In conclusion, this study demonstrated the positive impact of game-based learning in conveying technical concepts to non-technical students, with observed benefits in student motivation, behaviour, and educational performance. Nevertheless, additional research with a larger sample is required to validate the effectiveness of game-based learning in enhancing student performance, engagement, and motivation.

Acknowledgement

This research is funded by Collaborative Research Fund (CRF) cost centre (015ME0-382) at Universiti Teknologi Petronas.

References

Mazeyanti. (2023). Human cognition, *IT Game*, 100-130.

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis, *Journal of Computer Assisted Learning*, *35*(3), 407-420. Doi:10.1111/jcal.12347

Yusoff, Z, Kasmin, A, Shamshirband, S. & Chronopoulus, A.T. (2018). A survey of educational games as interaction design tools, *Education Information Technology*, 23, 393-418.

PLC-Based Industrial Automation and Control Education Through Virtual Labs: Integrating Digital Tools in Education 5.0

Kishore Bingi*, Rosdiazli Ibrahim, Madiah Omar
Universiti Teknologi PETRONAS, Malaysia.
*bingi.kishore@utp.edu.my

Introduction

Online e-learning's increasing popularity has led to a rise in the use of virtual labs, allowing students to carry out experiments and explore scientific ideas through online simulations (Bagal et al., 2018). These virtual labs offer numerous advantages, including enhanced accessibility. Students can conduct experiments and investigate concepts at any time and location, bridging the gap for those lacking access to physical labs (Gunawan et al., 2017). Moreover, virtual labs are more affordable than traditional labs, eliminating the need for specific buildings and equipment, thereby reducing setup and maintenance costs. They also promote active and blended learning, enabling students to engage in hands-on experiments and gain a deeper understanding of scientific concepts. They also bridge online and traditional classroom instruction (Kharki et al., 2021). In industrial automation, an open-source virtual lab called LabMIMO has been developed to teach nonlinear industrial automation, offering a free executable file download with eight experiments (Patel & Patel, 2022; Vries & May, 2019).

Motivated by the review, this paper introduces a virtual lab designed to teach and learn PLC-based industrial automation education. The virtual lab includes several experiments covering temperature and level control in a process tank. All experiments aim to create and execute a PLC ladder diagram to automate the process. The PLC online simulator is used for all experiments and programmed using ladder logic. Users can access it through any web browser without logging in. Users can also run the program and test various test cases.

Methodology

This section presents one of the process control experiments for developing a PLC ladder diagram-based virtual lab. The experiments include temperature and level control in a process tank. All experiments aim to create and execute a PLC program to automate the process. The process and instrumentation (P&ID) diagram for level control of a process tank is illustrated in Figure 1. The tank's top is open to manage the liquid level. It blocks

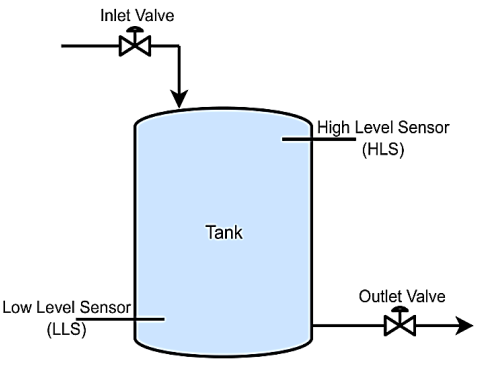


Figure 1 P&ID of a process tank for level control

the outlet flow when the liquid reaches the low level and allows the inlet flow until the high level is attained. Once it reaches a high level, the outlet flow is permitted, and the inlet flow is blocked. Thus, two-level sensors, LLS and HLS, are installed at the bottom and top of the tank to detect low and high levels.

Results and Discussions

The proposed virtual lab of PLC-based process control consists of four experiments described in the previous section. Table 1 provides the links to the virtual labs for all experiments. Since this is an open-source project, users can access these experiments using any web browser without logging in. Users can run the program and test the different test cases, as explained below.

Table 1 Links to access the virtual labs for all the experiments.

Lab Name	Virtual Lab Link
Level Control	https://app.plcsimulator.online/Pn4sMZMM0Zu94wj09XsS
Temperature Control	https://app.plcsimulator.online/l0vA6AW7a9uGXDJXiV85
Batch Mixing Process	https://app.plcsimulator.online/SejabhIyQ1WWk7ZAz3QH
Series Tanks Level Control	https://app.plcsimulator.online/Gd7U2t4WwuCAa1TA9Q6B
Parallel Tank Level and Temperature Control	https://app.plcsimulator.online/qotFMN2bTIijppZu4fGK

The virtual lab link in Table 1 allows users to access the PLC ladder diagram for any experiment. When the link is opened in a web browser, the PLC diagram will load, and a message will appear saying, "Diagram successfully loaded from the database". The ladder diagrams of all experiments are shown in Figure 2.

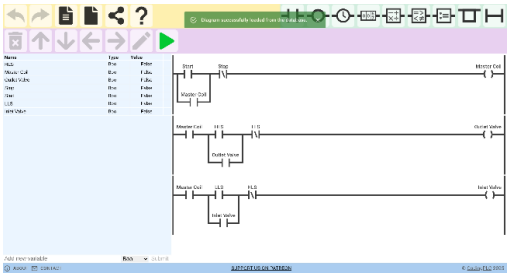


Figure 2 PLC ladder diagrams for level control from virtual labs.

In the PLC ladder diagram for level control shown in Figure 2, the first rung is responsible for latching a coil and master start-stop buttons. The second rung controls the Outlet Valve by detecting the HLS. The output valve is latched to keep the Outlet Valve open until the LLS is detected. The last rung works similarly - when the LLS is detected, it opens the inlet valve until the HLS is detected again. The inputs for this program include Start, Stop, LLS, and HLS. The outputs are the Inlet Valve and Outlet Valve. All these variables are defined in Figure 2. Users can initiate the simulation by clicking the "Start Simulation" button at the screen's top right corner.

Conclusion

This paper proposes the development of virtual labs for PLC-based industrial automation and control education. The lab includes experiments covering temperature and level control in a process tank, providing a cost-effective and reliable platform for students to learn and experiment with process control. The virtual lab enables students to engage in active learning and participate in practical exercises at their convenience, enhancing the learning experience and promoting teamwork and communication skills.

Acknowledgement

The authors acknowledge Universiti Teknologi PETRONAS, Malaysia, and Alliance University, India, for supporting this work under the International Collaborative Research Fund (ICRF), grant number 015ME0-379.

References

Bagal, K. N., Kadu, C. B., Parvat, B. J., & Vikhe, P. S. (2018). PLC based real time process control using SCADA and MATLAB. In *2018 Fourth International Conference on Computing Communication Control and Automation* (ICCUBEA), pp. 1-5, IEEE.

Gunawan, G., A. Harjono, H. Sahidu, & L. Herayanti. (2017). Virtual laboratory to improve students' problem-solving skills on electricity concept, *Jurnal Pendidikan IPA Indonesia, 6*(2), 257-264.

Kharki, K. E., Berrada, K., & Burgos, D. (2021). Design and Implementation of a Virtual Laboratory for Physics Subjects in Moroccan Universities, *Sustainability*, *13*(7), 3711-3711.

Patel, A., & Patel, D. J. (2022). LabMIMO: An Open-source Virtual Laboratory for Process Control. *Journal of Engineering Education Transformations*, 36(1), 104-110.

deVries, L. E. & May, M. (2019). Virtual laboratory simulation in the education of laboratory technicians-motivation and study intensity, *Biochemistry and Molecular Biology Education, 47*(3), 257-262.

Enhancing Engineering Education in Drilling Fluids and Cementing Technology through Active Learning Strategies

Raja Rajeswary Suppiah*
Universiti Teknologi PETRONAS, Malaysia.
*rajarajeswary@utp.edu.my

Introduction

The field of petroleum engineering, particularly the study of drilling fluids and cementing technology, is critical to the oil and gas industry. Given its technical complexity and operational importance, practical education in these areas is essential for preparing the next generation of engineers. Traditional pedagogical approaches in this domain often emphasise theoretical knowledge with limited opportunities for practical application. However, recent advancements in educational methodologies suggest that active learning strategies can significantly enhance understanding and retention in complex technical subjects. This paper explores how active learning strategies can be employed to improve education in drilling fluids and cementing technology, providing a framework for their implementation and evaluating their effectiveness.

Methods

Active learning encompasses a range of pedagogical techniques that shift the focus from passive reception of information to active engagement with the material. For drilling fluids and cementing technology, several active learning strategies can be particularly effective:

1. Case-Based Learning: Utilising real-world case studies and scenarios allows students to apply theoretical knowledge to practical problems. Case studies related to drilling failures, cementing issues, and successful operations can be used to foster critical thinking and problem-solving skills. Students can analyse these cases, propose solutions, and discuss their approaches in group settings, enhancing their understanding of complex concepts.

2. Simulation and Modelling: Advanced software tools and simulators can replicate real-world drilling and cementing operations. Students gain hands-on experience managing drilling fluids and cementing processes by interacting with these tools, allowing them to visualise and experiment with different scenarios. Simulation-based exercises can also include troubleshooting and optimisation tasks, reinforcing students' problem-solving abilities.

3. Laboratory Work: Incorporating laboratory experiments where students can physically interact with drilling fluids and cementing materials is invaluable. Through hands-on experiments, students can observe the properties of different fluids, test various additives, and understand the chemistry and mechanics involved. Laboratory work also provides practical experience in mixing, testing, and analysing drilling fluids and cement slurries.

4. Project-Based Learning: Engaging students in group projects where they design and implement a drilling or

cementing plan encourages collaboration and application of theoretical knowledge. Projects can involve creating a well with specific constraints, optimising drilling fluid properties for particular conditions, or developing a cementing strategy to address unique challenges. This approach helps students integrate and apply their knowledge in a meaningful context.

5. Interactive Lectures: Transforming traditional lectures into interactive sessions by incorporating real-time polling, quizzes, and discussion prompts can enhance student engagement. These techniques encourage active participation and provide immediate feedback, allowing students to grasp and apply complex concepts in real-time.

Results and Discussion

A structured approach is necessary to integrate these active learning strategies into the curriculum effectively. The following framework outlines key steps for implementation:

1. Curriculum Design: Revise the curriculum to incorporate active learning components. Identify key drilling fluids and cementing technology topics where active learning can be most beneficial and design corresponding activities and assessments.

2. Instructor Training: Train instructors on active learning techniques and using simulation tools and case studies. Practical training ensures that educators are equipped to facilitate active learning and create an engaging learning environment.

3. Resource Development: Develop or source the necessary resources, such as simulation software, laboratory equipment, and case study materials. Ensure that these resources are accessible and integrated into the course structure.

4. Assessment and Feedback: Implement assessment methods that evaluate theoretical understanding and practical skills. Include formative assessments, such as quizzes and peer evaluations, as well as summative assessments, like project reports and presentations. Provide timely and constructive feedback to guide students' learning processes.

5. Continuous Improvement: Regularly review and update the active learning components based on student feedback and performance outcomes. Engage in reflective practice to identify areas for improvement and adapt strategies to meet evolving educational needs.

Conclusion

Enhancing engineering education in drilling fluids and cementing technology through active learning strategies offers significant potential for improving student outcomes. By incorporating case-based learning, simulation and modeling, laboratory work, project-based learning, and interactive lectures, educators can create a more engaging and practical learning experience. The proposed framework for implementation and evaluation provides a structured approach to integrating these strategies into the curriculum. Ultimately, adopting active learning methods can bridge the gap between theoretical knowledge and practical application, preparing students for the complexities of the petroleum industry.

Acknowledgement

Our heartfelt thanks go to the Department of Petroleum Engineering, Universiti Teknologi PETRONAS for providing us with the necessary facilities, resources, and a conducive environment for learning and research. Special recognition goes to the Final year Drilling Fluids and Cementing students for their invaluable assistance during our practical sessions and data collection.

Reference

Anderson, C., & Day, K. (2005). Purposive environments: Engaging students in the values and practices of history. *Higher Education*, *49*(3), 319–343. Doi:10.1007/s10734-004-6676-y

Alt, D., Raichel, N., & Naamati-Schneider, L. (2022). higher education students' reflective journal writing and lifelong learning skills: insights from an exploratory sequential study. *Frontiers in Psychology*, *12*. Doi:10.3389/fpsyg.2021.707168

Cheng, G., Ramirez-Amaro, K., Beetz, M., & Kuniyoshi, Y. (2019). Purposive learning: Robot reasoning about the meanings of human activities. *Science Robotics*, *4*(26). Doi:10.1126/scirobotics.aav1530

Fitzsimons, M. (2014). "Engaging students' learning through active learning," *Irish Journal of Academic Practice*, 3(1),

Gleason, B. L., Peeters, M. J., … & Denetclaw, T. H. (2011). An active-learning strategies primer for achieving ability-based educational outcomes. *American Journal of Pharmaceutical Education*, *75*(9), 186–186. Doi:10.5688/ajpe759186

Guthrie, R. W., & Carlin, A. (2004). Waking the Dead: Using interactive technology to engage passive listeners in the classroom. Association for Information Systems AIS Electronic Library (AISeL). https://knilt.arcc.albany.edu/images/2/20/Guthrie_%26_Carlin_Waking_the_Dead.pdf

Hartikainen, S., Rintala, H., Pylväs, L., & Nokelainen, P. (2019). The concept of active learning and the measurement of learning outcomes: A review of research in engineering higher education. *Education Sciences*, *9*(4), 276. Doi:10.3390/educsci9040276

Harvey, M., Lloyd, K., McLachlan, K., Semple, A.-L., & Walkerden, G. (2020). Reflection for learning: a scholarly practice guide for educators. Advance HE. https://www.advance-he.ac.uk/knowledge-hub/reflection-learning-scholarly-practice-guide-educators

Killian, M., & Bastas, H. (2015). The Effects of Team-Based Learning on Students' Attitudes and Students' Performances in Introductory Sociology Classes. *Journal of the Scholarship of Teaching and Learning*, 53–67. Doi:10.14434/josotl.v15i3.12960

Matthews, N., Kilgour, L., Christian, P., Mori, K., & Hill, D. M. (2014). Understanding, Evidencing, and Promoting Adolescent Well-Being. *Youth & Society*, *47*(5), 659–683. Doi:10.1177/0044118x13513590

Meyer, C. & Thomas B., J. (1994). Promoting active learning: strategies for the college classroom. https://eric.ed.gov/?id=ED358757

Rothkopf, E. Z. (1981). A macroscopic model of instruction and purposive learning: An overview. *Instructional Science*, *10*(2), 105–122. https://doi.org/10.1007/bf00132513

Schindler, L. A., Burkholder, G. J., Morad, O. A., & Marsh, C. (2017). Computer-based technology and student engagement: a critical review of the literature. *International Journal of Educational Technology in Higher Education*, *14*(1). Doi:10.1186/s41239-017-0063-0

Thorburn, M. (2020). "Personal well-being and curriculum planning: a critical comparative review of theory, policy and practice coherence," *Educ Rev (Birm)*, *72* (6). Doi:10.1080/00131911.2018.1552660.

Zayapragassarazan, S. & Kumar, (2012). "Active Learning Methods. NTTC Bulletin," *NTTC Bulletin*, *19*(1), 2012.

Implementing Technology and Digital Innovation for Capstone Design Project in Civil Engineering

Ahmad Mahamad Al-Yacouby
Universiti Teknologi PETRONAS, Malaysia.
*ahmad.alyacouby@utp.edu.my

Introduction

To respond to the digital transformation in the industry to adopt Industry 4.0 in building information modelling (BIM)-the construction industry developed a new approach to engineering capstone projects to meet the industry demand for graduate students equipped with technology and digital innovation required by the industry. Construction Industry 4.0 represents the application of digital technology in the construction industry to ensure that the engineering, construction, and operation industries are conducive to the sustainable development of society, the economy, and the environment (Schönbeck, Löfsjögård, & Ansell, 2020). The Architecture, Engineering, Construction, and Operations (AECO) industry is integral to the construction sector, providing architectural design, engineering design, construction services, and operations (Gerrard et al., 2010). The history and development of digital technology in civil engineering can be traced back to the rise of computer science and information technology and the gradual application of digital tools in engineering design and construction (Shen X., Liang Q. & Jiang G., 2021). From the first Computer-aided Design (CAD) software to modern Building Information Modelling (BIM) and smart city technology, digital technology has profoundly changed the face of civil engineering, improving engineering efficiency, accuracy, and sustainability (Yang, J., 2021). For additional references on the topic one can refer to Waqar et al. (2024), Vilutiene et al. (2019) and Yilmaz et al. (2023).

Research Methodology

Capstone Desing Project (CDP) is arguably the most critical Bachelor of Civil Engineering course. It combines all the complex engineering problems and design elements the students have learned in the past three years of the Civil Engineering program. Hence, the CDP course is usually offered in the final year since it requires fundamental knowledge acquired by each student to incorporate multiple civil engineering designs into one complex project. CDP brings the experience of how an engineering consultancy company works on a day-to-day project. Therefore, students who undertake internships at an engineering consulting firm may have an added advantage, such as applying engineering software. CDP comprised a combined six credit hours in two consecutive semesters. This is 100% coursework with various components of assessments, tests, presentations, and engineering design reports. Conventional to BIM scope alignment for CDP 1 and CDP 2 is presented in Figures 1 and 2, respectively.

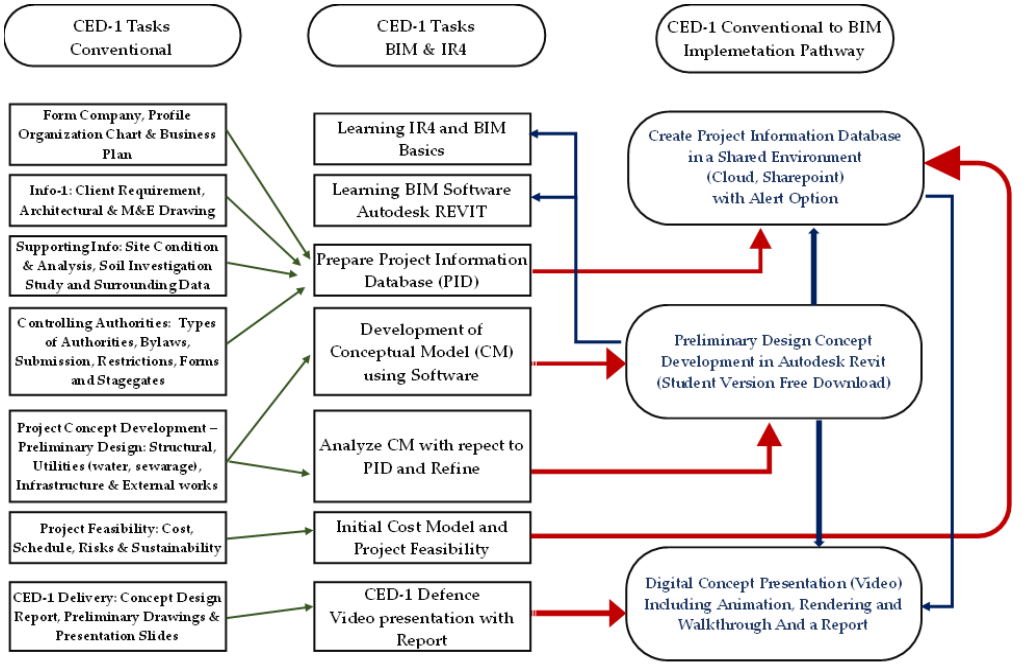


Figure 1 Conventional to BIM scope alignment for CDP 1

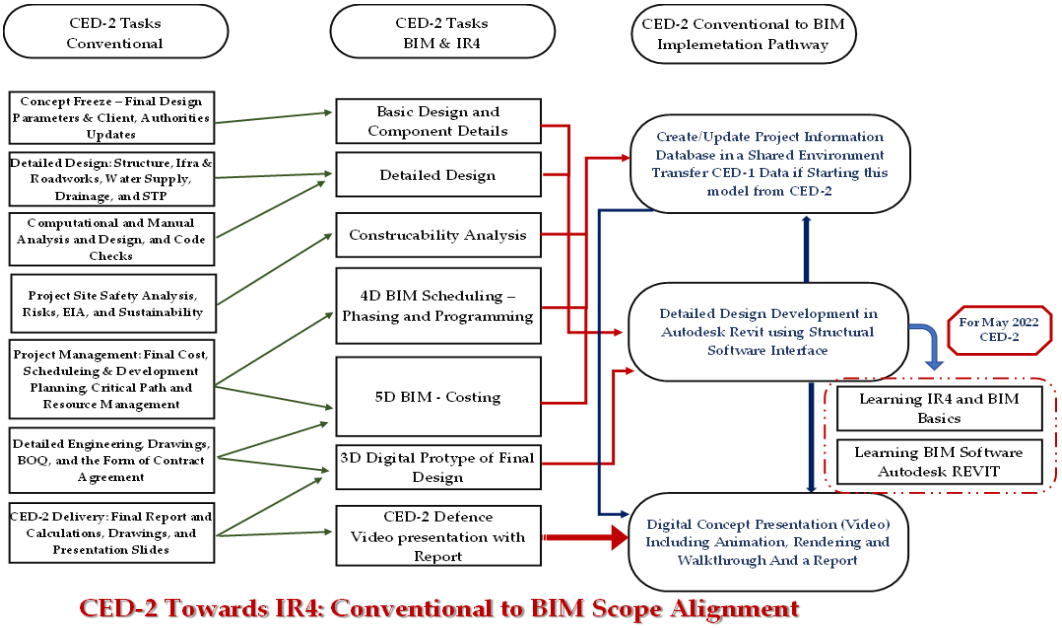


Figure 2 Conventional to BIM scope alignment for CDP2

The methodology adopted in this study consists of a questionnaire survey to investigate how BIM technology helped the final-year students understand the civil engineering design process, the selection of materials, and the coordination of complex projects. Overall, 143 students from various batches participated, with a response rate of 96%.

Results and Discussions

The effects of technology and digital innovation on the capstone design project in civil engineering. Based on BIM technology, the study was conducted using an online questionnaire survey. Among the respondents, 67% were male, while 33% were female. The results show that 84% of the respondents strongly believe that modelling CDP using the BIM platform helped them to understand the design process for civil engineering projects. Similarly, 91% of the respondents strongly agree that modelling CDP using the BIM platform enabled them to understand the construction process of civil engineering projects.

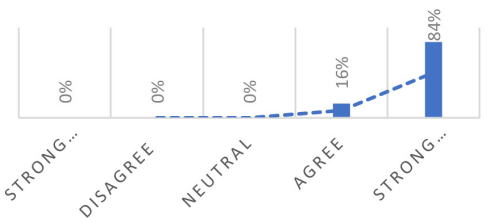


Figure 3 Effects of using BIM in better understanding the Design Process

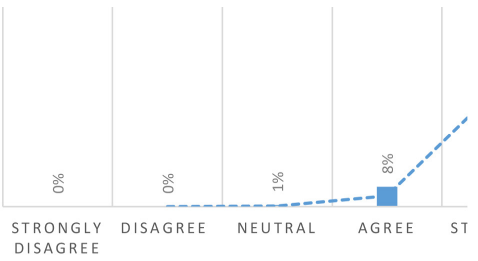


Figure 4 Effects of using BIM in better understanding the Construction Process

Conclusion

This paper addresses the effects of Technology and Digital Innovation on the Capstone Design Project in Civil Engineering based on BIM.

Acknowledgment

The authors would like to acknowledge the continued support by Universiti Teknologi PETRONAS (UTP)

References

Schönbeck, P., Löfsjögård, M., & Ansell, A. (2020). Quantitative Review of Construction 4.0 Technology Presence in Construction Project Research, *Buildings*, *10*(10), 173-173.

Gerrard, A., Zuo, J., Zillante, G., & Skitmore, M. (2010). Building information modelling in the Australian architecture, engineering, and construction industry. In Isikday, U., & Underwood, J (eds.) H*andbook of Research on Building Information Modelling* and Construction Informatics: Concepts and Technologies. *Information Science Reference*, New York: IGI Global Publishing pp. 521-545.

Xinfu, S, Qingqing, L., & Guofu, J. (2021). Research on System architecture and key technologies of Civil Engineering Digital Training Platform based on BIM technology [J]. *Western Transportation Science and Technology,* (12), 198-200.

Yang, J., (2021) Application of BIM technology in construction cost management of building engineering. *Journal of Physics: Conference Series,* 2037(1), 012046.

Waqar, A., Shafiq, N., Othman,I., …& Almujibah, H.R. (2024) Examining the impact of BIM implementation on external environment

of AEC industry: a PEST analysis perspective. *Developments in the Built Environment*, 17, 100347.

Vilutiene, T., Diana K. , Hosseini, M. R., Pellicer, E. & Zavadskas, E. K. (2019). Building information modeling (BIM) for structural engineering: A bibliometric analysis of the literature. *Advances in Civil Engineering*, 1, 5290690.

Yilmaz, G., Akcamete, A., & Demirors, O. (2023). BIM-CAREM: Assessing the BIM capabilities of design, construction and facilities management processes in the construction industry. *Computers in Industry*, *147*, 103861.

Transforming Education in Malaysia: A Case Study of Multidisciplinary Project-Based Learning for Future-Ready Graduates at Universiti Teknologi Petronas

Zulkifli Merican Aljunid Merican
Universiti Teknologi PETRONAS, Malaysia.
*zulkifli.aljunid@utp.edu.my

Introduction

In recent years, Malaysian higher education has increasingly focused on innovative pedagogies to develop graduates equipped for future workforce demands. One such initiative at Universiti Teknologi PETRONAS (UTP) is the Integrated Project-based Active Learning (IPAL) approach. IPAL emphasises active, multidisciplinary learning to enhance student engagement, foster critical thinking, and improve practical problem-solving skills in real-world contexts. This study evaluates IPAL's effectiveness in two courses, Molecular Spectroscopy (YBB2093) and Hydrocarbon & Petrochemical (YBB2103), assessing whether this approach can bridge the gap between theoretical understanding and practical application.

Problem Statement

Traditional lecture-based teaching methods often fail to deeply engage students in science and engineering disciplines, resulting in a superficial understanding of complex subjects (Gustin et al., 2018). Key challenges include limited active participation and a lack of real-world relevance in learning, which the IPAL method aims to address by fostering collaborative, hands-on learning experiences.

Educational Framework

The IPAL approach aligns with constructivist learning theories, which advocate for experiential and collaborative learning to build knowledge. This aligns with Vygotsky's emphasis on social interaction in learning (Vygotsky, 2020) and Kolb's experiential learning model, which promotes active participation to deepen understanding (Kolb & Kolb, 2017). IPAL's multidisciplinary focus aims to produce graduates who can think critically and work collaboratively across diverse fields (Hyytinen et al., 2019), aligning with Malaysia's push toward future-ready education.

Methodology

A significant aspect of the methodology involves engaging groups of students in a single assignment that requires them to analyse a selection of given chemical compounds, namely the popular Ziegler-Natta, metal-organic framework HKUST catalysts or the first and second generations of the Grubbs catalysts. In doing so, they are required to leverage various spectroscopic techniques for structural characterisations. This deepens their understanding of the complex interplay between theory and practice in chemical synthesis, characterisation, and industrial applications and

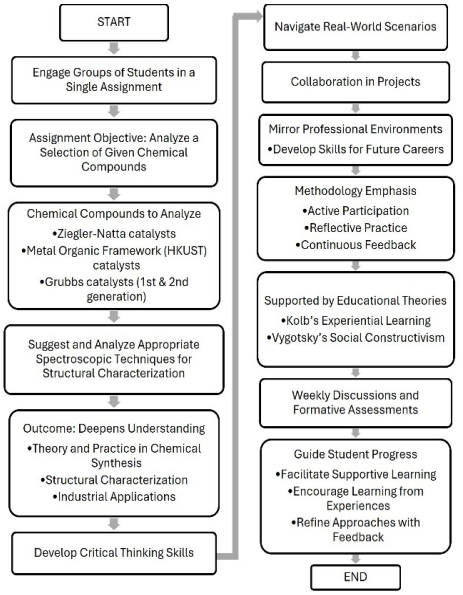


Figure 1 Flowchart of a Structured Methodology for Engaging Students in Collaborative Analysis of Hydrocarbon and Petrochemical Compounds through Spectroscopic Techniques and Reflective Learning

fosters critical thinking as students navigate real-world scenarios' challenges. Moreover, the collaborative nature of these projects mirrors professional environments, enabling students to develop essential skills crucial for their future careers. The methodology emphasises active participation, reflective practice, and continuous feedback, all supported by the established Kolb's Experiential Learning and Vygotsky's Social Constructivism educational theories. Weekly discussions and formative assessments guide student progress and facilitate a supportive learning environment where students can learn from their experiences and refine their approaches based on constructive feedback (Figure 1).

Results and Discussion

The study analysed formative assessment scores of 31 undergraduate second-year students in Molecular Spectroscopy and Hydrocarbon & Petrochemical courses utilising statistical and visualisation techniques to identify performance patterns. This data-driven approach offers insights into the distribution of scores, the relationship between performances in each course, and areas for improvement. The analysis included descriptive statistics, correlation assessments, and graphical representations, such as boxplots, histograms, and scatter plots, to capture the nuances of student performance (Alhadad, 2018).

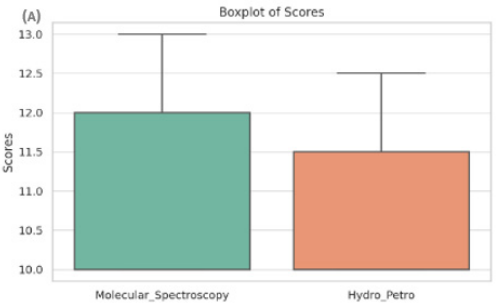
The data revealed several key insights into student performance (Figure 2),

1. *Descriptive Statistics*

Students' scores in Molecular Spectroscopy were higher, with a mean of around 11.7, while Hydrocarbon & Petrochemical scores averaged 10.7. This discrepancy indicates that students found Molecular Spectroscopy more accessible than Hydrocarbon & Petrochemical, possibly due to differences in course content or teaching methods (Zepke & Leach, 2019).

2. *Correlation Analysis*

The study found a weak positive correlation ($r = 0.15$) between the two subjects, suggesting that success in one course does not necessarily translate to the other. This weak relationship may indicate that different skill sets are required for each course, reinforcing the need for interdisciplinary learning approaches to bridge these skill gaps (Thang et al., 2021).



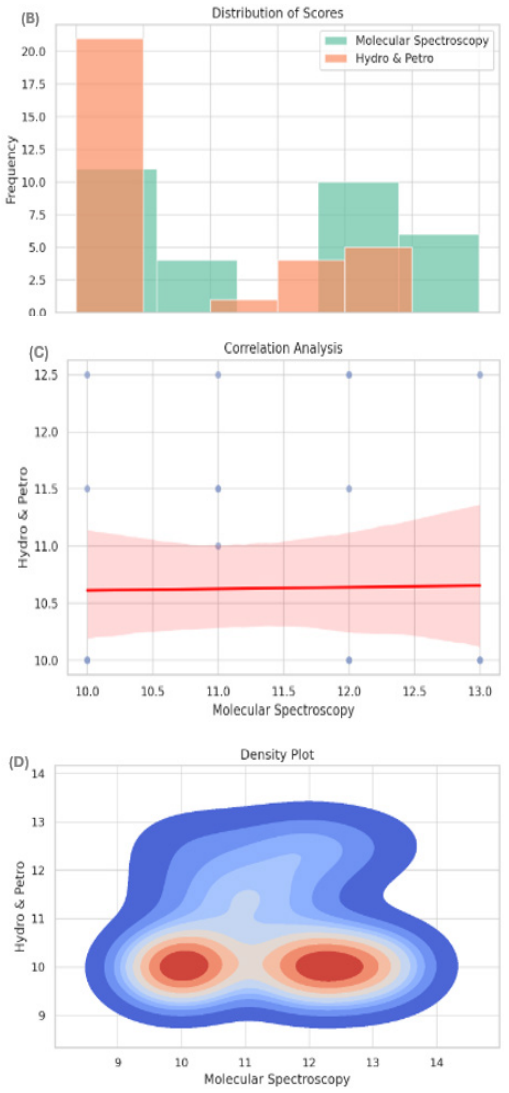


Figure 2 Evaluation of IPAL Effectiveness Using Formative Assessment Scores: Boxplot scores (A); Distribution of Scores (B); Correlation Analysis (C); and Density Plot (D).

3. *Boxplot Analysis*

Boxplots of the scores revealed a higher median for Molecular Spectroscopy, with few outliers in both courses. The consistent scoring trends highlight an opportunity to explore course-specific challenges and provide targeted support to enhance overall performance.

4. *Histogram Analysis*

The histogram showed that most students scored lower in Hydrocarbon & Petrochemicals, suggesting potential challenges in grasping the subject. In contrast, Molecular Spectroscopy scores were more evenly distributed, indicating a more balanced level of understanding among students (Le et al., 2018).

5. *Scatter Plot and Trend Line*

The scatter plot with a regression line showed almost no significant trend, further supporting the weak correlation between the two subjects. This result indicates that students' mastery of concepts in one subject does not automatically translate to success in another.

6. *Density Plot*

Density analysis showed two distinct clusters, hinting at subgroups within the class that might differ in prior knowledge or engagement levels. These insights can inform the design of future IPAL interventions, potentially introducing differentiated instruction to cater to diverse learning needs (Sormunen et al., 2020).

Recommendations

Based on the insights from the analysis, the following recommendations are proposed to enhance the effectiveness of the IPAL approach,

1. Conduct an Assessment Review:
   Review the difficulty level of assessments and the grading criteria for both subjects to ensure consistency. Standardising rubrics and grading practices can help create a balanced evaluation system across courses (Shepard et al., 2018).

2. Cross-Disciplinary Integration:
   The weak correlation between scores suggests students may benefit from a more integrated curriculum emphasising

interdisciplinary skills. Developing projects that require knowledge from multiple subjects could encourage students to apply concepts from both courses, fostering a holistic learning experience (Molderez & Fonseca, 2017).

3. Targeted Support:
   The density plot's indication of performance clusters indicates the need for differentiated instruction. Identifying students who struggle early on allows for targeted interventions, such as supplementary workshops or peer-assisted learning sessions (Kolb & Kolb, 2017).

4. Improving the Balance Between Theoretical and Practical Skills:
   The weak correlation between performance in Molecular Spectroscopy and Hydrocarbon & Petrochemicals suggests that students may be developing skills in silos rather than integrating their knowledge across disciplines. This is counterproductive to IPAL's goal of fostering interdisciplinary learning and critical thinking.

Conclusion

This study highlights the effectiveness of IPAL in promoting active learning and interdisciplinary understanding at UTP. However, to maximise its potential, IPAL should focus on consistent assessment standards, cross-subject integration, and targeted support for varied student groups. These improvements align with UTP's mission of preparing future-ready graduates to tackle complex, multidisciplinary challenges. As Malaysian higher education continues to evolve, approaches like IPAL can set a precedent for fostering versatile, skilled professionals who can adapt to the demands of a dynamic job market.

Acknowledgement

The author would like to acknowledge the Department of Fundamental and Applied Sciences at Universiti Teknologi PETRONAS for supporting this study. Special thanks to ChM. Ts. Dr. Lim Jun Wei from the Department of Fundamental and Applied Sciences for his invaluable contributions in co-teaching one of the IPAL courses and providing the student performance data, which significantly enhanced the interdisciplinary learning experience for students.

References

Alhadad, S. S. J. (2018). Visualising data to support judgement, inference, and decision making in learning analytics: Insights from cognitive psychology and visualisation science. *Journal of Learning Analytics*, *5*(2).

Gustin, M. P., Abbiati, M., Bonvin, R., Gerbase, M. W., & Baroffio, A. (2018). Integrated problem-based learning versus lectures: a path analysis modelling the relationships between educational context and learning approaches. *Medical Education Online*, *23*(1), 1489690.

Hyytinen, H., Toom, A., & Shavelson, R. J. (2019). Enhancing *scientific* thinking through the development of critical thinking in higher education. In Murtonen, M. & Balloo, K.,(eds.) *Redefining Scientific Thinking for Higher Education,* (pp. 59–78), London: Palgrave Macmillan

Kolb, D. A., & Kolb, A. Y. (2017). Experiential learning theory as a guide for experiential educators in higher education. *ELTHE: A Journal for Engaged Educators*, 1(1), 7-44.

Le, H., Janssen, J., & Wubbels, T. (2018). Collaborative learning practices: teacher and student perceived obstacles to effective student collaboration. *Cambridge Journal of Education*, *48*(1), 103-122.

Molderez, I., & Fonseca, E. (2018). The efficacy of real-world experiences and service learning for fostering competences for sustainable development in higher education. *Journal of Cleaner Production*, *172*, 4397-4410.

Shepard, L. A., Penuel, W. R., & Pellegrino, J. W. (2018). Using learning and motivation theories to coherently link formative assessment, grading practices, and large-scale assessment. *Educational Measurement: Issues and Practice*, *37*(1), 21-34.

Sormunen, K., Juuti, K., & Lavonen, J. (2020). Maker-centered project-based learning in inclusive classes: Supporting students' active participation with teacher-directed reflective discussions. *International Journal of Science and Mathematics Education*, *18*, 691-712.

Vygotsky, L. S. (2020). *Mind in Society: The Development of Higher Psychological Processes.* Harvard: Harvard University Press.

3D Printing Technology Applications for Enhanced Teaching and Learning for Engineering Drawing Education

Khurram Altaf*
[1]Universiti Teknologi PETRONAS, Malaysia.
*khurram.altaf@utp.edu.my

Introduction

The engineering education area has long relied on technical drawing to convey design and manufacturing principles. Engineering Drawing, an introductory course for engineering education, highlights the understanding of 2D interpretations of 3D objects, including orthographic projections, isometric drawings, and sectional views. However, one of the substantial issues many students face in this course is the ability to visualise complex 3D objects from 2D drawings, limiting their understanding of geometric relationships and creating problems in their spatial or three-dimensional cognitive skills.

New opportunities have emerged to tackle these challenges with emerging digital technologies, specifically 3D printing (3DP) or Additive Manufacturing (AM) technologies. 3D printing, called Additive Manufacturing (AM), allows for fabricating three-dimensional (3D) physical models from digital design data. In the context of Engineering Drawing, this technology offers a transformative tool for enhancing teaching and learning. By producing tangible models that students can manipulate and examine, 3D printing enables learners to grasp abstract geometric concepts and visualise the physical relationships between components in ways that are impossible with 2D representations alone.
The integration of 3D printing into Engineering Drawing instruction provides numerous pedagogical benefits. It enables instructors to create customised models of complex components, facilitates hands-on learning, and promotes active engagement by exploring real-world objects. Students can interact with these models to better understand the nuances of engineering design, assembly, and manufacturing processes. Additionally, 3D printing fosters an experiential learning environment where students can iterate on designs, experiment with physical prototypes, and receive immediate feedback through tactile interaction with models.

This paper explores the applications of 3D printing technologies in the Engineering Drawing course to enhance teaching effectiveness and improve student learning outcomes. By examining the benefits and challenges of incorporating 3D printing into engineering education, the aim is to provide insights into how this technology can bridge the gap between theoretical concepts and practical applications, eventually preparing students for real-world engineering tasks.

Literature Review

Ford and Minshall (2019) studied the emerging additive manufacturing and 3D printing technologies for industrial skills and the opportunities for new teaching practices in various educational settings. They investigate

these practices across a wide range of education disciplines and courses. The study creates distributed bodies of research to provide a literature review of where and how 3D printing is used in the education system. They studied the applications of 3D printing in schools and universities in six use categories,

1. To teach students about 3D printing.
2. To teach educators about 3D printing.
3. To support technology during teaching.
4. To produce artefacts that aid learning.
5. To create assistive technologies.
6. To support outreach activities.

Ahmed and Zaneldin (2020) studied the challenges educators face in integrating 3D printing technology into a traditional engineering course. The study aims to present the challenges and achievements of integrating 3D printing technology in teaching design and manufacturing courses in the mechanical engineering department to enhance students' skills and engagement with the course material. Şimşir and Yavuz (2023) studied the concepts among the problems experienced by all students and teachers throughout the education period. They clarified that the easiest way to explain these concepts is to visualise the subject to be explained. Technical drawing course is one of these courses. In particular, the instructors have difficulties defining the course's basic subjects, such as three views, perspective drawing, and cross-sectional views. Generally, trainers use projectors to increase the visualisation. However, some students still do not understand the topics. It has been shown in many studies that students can better understand the subjects they practice and observe. Additive manufacturing and 3D printing technologies can help students learn new ideas and increase their imagination. With 3D printing technology, educational materials are necessary to understand the subjects quickly, thanks to 3D printers. In this way, the subjects in the technical drawing course were easily understood by the students.
Banjanin et al. (2020) explained that 3D printing is constantly growing in many manufacturing industries and educational institutions. Prototyping, proof of concept, and 3D printing are undoubtedly spreading their applications in manufacturing and aiding research and teaching processes. Their study focuses on various initiatives that support the educational process and the methods for implementing 3D printing in education. Their research discussed the potential of 3D printing for educational purposes of graphic engineering and design students. They also developed a methodology for getting theoretical and practical knowledge through a designed catalogue of 3D printing parameters to introduce undergraduate students to one of the most used and affordable 3D printing techniques known as Fused Deposition Modelling (FDM), and to provide them with basic knowledge of 3D printing parameters which further on can be expanded and supplemented.

Ma et al. (2019) described that mechanical engineering drawing is required for professional courses for students majoring in mechanical disciplines. They explained that the students lack practical engineering experience and spatial imagination. For this reason, it is difficult for them to image plane figures as 3D shapes and to establish the concept of space. Therefore, teaching aids can be of good help to students. With the development and progress of digital technologies, 3D printing technology was applied in teaching aid manufacturing, making manufacturing costs low and manufacturing fast and convenient. Applying 3D printing technology in Mechanical Drawing class will help students establish spatial imagination and stimulate their study interests.

Research Methodology

The current study employed a technique/ approach to evaluate the impact of 3D printing technology on teaching and learning for the Engineering Drawing course. The methodology was divided into stages: selection

and preparation of 3D models, implementation of 3D printing to fabricate the teaching model, and applying the concept during the actual engineering drawing session.

The study was conducted during the teaching semester with undergraduate engineering students enrolled in an introductory first-year Engineering Drawing course at Universiti Teknologi Petronas (UTP). For the study, 3D models were designed based on the key engineering components and drawings taught in the course (Figure 1). These models were created using CAD (Computer-Aided Design) software, such as Space Claim Design Modeler and AutoCAD (Figure 2), and printed using an FDM (Fused Deposition Modelling) 3D printer (Figure 3). The models included a simple geometric shape to demonstrate the basics of projections and sectioning and sectional models of parts with internal features visualisation to visualise hidden elements.

These models were given to students during specific Engineering lab sessions where complex geometries and spatial reasoning were crucial to understanding the material.
The students were initially taught using traditional methods, including PowerPoint slides, 2D technical drawings, textbook illustrations, and CAD demonstrations. Students were asked to independently interpret and create engineering drawings based on 2D representations. In addition to traditional methods, the student received physical 3D printed models corresponding to the lecture content. During the session, the instructor demonstrated how the models related to the 2D drawings and allowed students to manipulate and explore the models to enhance their spatial understanding.

The student's assessment performance was evaluated through assignments and verbal reasoning, focusing on the accuracy, precision, and complexity of the drawings.

The instructor maintained a log of classroom activities, student engagement, and common challenges faced by each group. This qualitative data provided insight into student participation levels, comprehension issues, and the overall effectiveness of 3D models as teaching aids. Student performance in assignments was analysed to identify the performance.

Some Limitations

Several limitations were considered in the study. First, the small sample size may limit the generalizability of the results. Second, time constraints restricted the number of 3D models that could be printed, potentially reducing the full range of concepts that could be demonstrated. Lastly, the novelty of 3D printing technology may have introduced a bias, as students may have been more engaged simply due to the use of new technology rather than its direct impact on learning outcomes. Through this methodology, the study systematically assessed the effect of 3D printing technology on enhancing spatial reasoning, academic performance, and student engagement in the Engineering Drawing course.

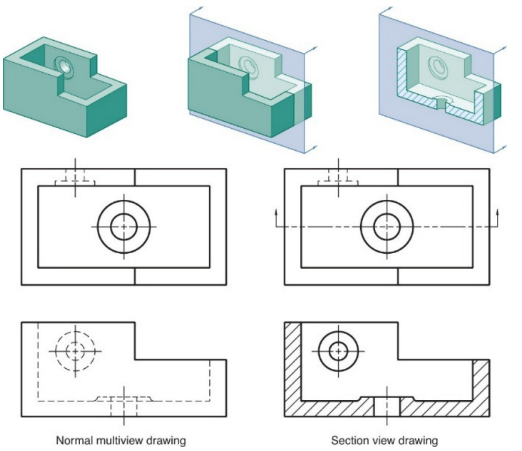


Figure 1 A typical illustration of sectional views

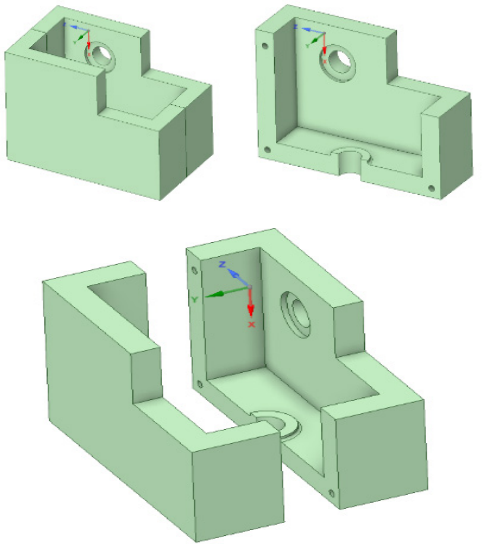


Figure 2 Creating 3D models for the sectional views

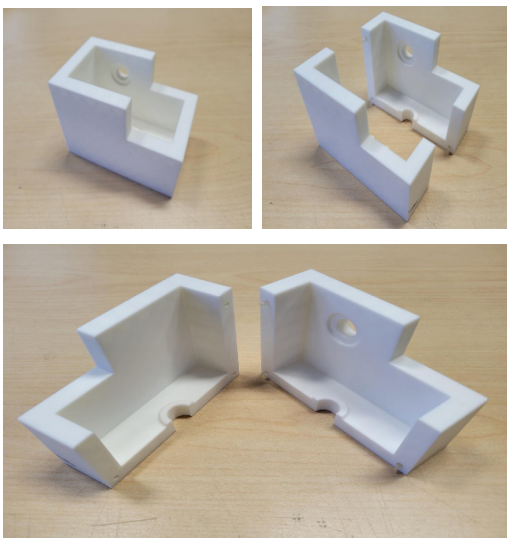


Figure 3 3D printed models for the sectional views Engineering Drawing lab session

Result and Discussions

The incorporation of 3D printing technology into the Engineering Drawing course can create significant improvements in both student engagement and learning results. Through some activities during Engineering Drawing lab sessions using 3D printed teaching aids during the semester, the analysis and results demonstrated the benefits of incorporating 3D models into the teaching and learning process.

Improved 3-Dimensional/Spatial Visualisation Skills: Students who used 3D printed models during the lab sessions showed improvement in spatial visualisation. The average scores of students who engaged with 3D models increased. This suggests that physical models helped students better understand the relationships between 2D projections and their corresponding 3D objects.

Increased Student Engagement and Motivation: Student engagement levels increased with the introduction of 3D printed models. Students showed that working with 3D-printed models made the coursework more interesting and engaging. The hands-on nature of the technology allowed students to actively experiment and collaborate in ways that are better than traditional teaching methods.

Challenges: Despite the positive outcomes, some challenges were observed. The time required to prepare and print 3D models occasionally slowed the instructional process, mainly when many students needed access to the same models. Also, some students required initial guidance in effectively using the 3D models, indicating the need for an orientation on leveraging this teaching aid for learning. However, these issues were minor and can be managed with prior planning.

Introducing 3D printing technology into the Engineering Drawing course significantly enhanced students' understanding of 3-dimensional/spatial relationships, increased their engagement with the subject matter, and improved their overall academic performance. These results underscore the value of incorporating modern educational technologies to supplement and enhance traditional engineering education.

Conclusion

Integrating printing technology with the teaching and learning of the Engineering Drawing course can potentially enhance student comprehension and instructional effectiveness. By transforming visual 2D representations into physical 3D models, students can quickly grasp complex geometrical concepts and improve their spatial visualisation skills in engineering education. This interactive learning approach enables students to relate theoretical drawings to physical objects directly, promoting better understanding and retaining key concepts such as orthographic projections, sectional views, and assembly drawings.

In conclusion, 3D printing technology offers an innovative and effective way to improve the teaching and learning of Engineering Drawing courses. Providing a more immersive and practical educational experience can equip students with the technical skills they need for success in academia and industry. As 3D printing technology evolves more shortly, its applications in engineering education are expected to expand, offering better opportunities for enhanced teaching and learning.

Another observation about the current study was that it was primarily qualitative, with only a limited number of students engaged. This was to analyse students' initial results and responses to the application of 3D printing in the Engineering Drawing course. It is planned that, in future investigations, more quantitative-level studies will be conducted using similar approaches and analyse the data to be presented.

Acknowledgement

The authors acknowledge the financial support of this study by Prototype grant No. 015PBA-037.

References

Ford, S., & Minshall, T. (2019). Invited review article: Where and how 3D printing is used in teaching and education. *Additive Manufacturing*, 25(25), 131–150.

Ahmed, W., & Zaneldin, E. K. (2020). The Innovation of Using 3D Printing Technology in Mechanical and Manufacturing Engineering. *2020 IOP Conf. Ser.: Mater. Sci. Eng., 938*(1), 012002.

Şimşir, E., & Yavuz, İ. (2023). Use of 3D Printers in Engineering Education: Example of a Technical Drawing Lesson. *Bilsel International Gordion Science Researches Congress*, 29-30 September 2022.

Banjanin, B., Pál, M., Dimovski, V., Adamovic, S., & Lilić, A. (2020). 3D printing in the education of graphic engineering and design students. *10th International Symposium on Graphic Engineering and Design*. Doi:10.24867/grid-2020-p51

Ma, J., Yu, H., Hao, R., & Liu, H. (2019). Application of 3D Printing Teaching Aids in Mechanical Drawing Class. *Proceedings of the 5th International Conference on Social Science and Higher Education (ICSSHE 2019)* Doi:10.2991/icsshe-19.2019.20Bertoline

Enhancing Student and Learning Experience Based on EDA Tools Coupled with Goals Framework

Soeung Socheatra*, Norashikin Yahya, Micheal Drieberg
Universiti Teknologi PETRONAS, Perak, Malaysia.
*socheatra.s@utp.edu.my

Introduction

Several teaching and learning methods have been developed to enhance and facilitate students' learning experience in every aspect. It has been the mainstream in the education system that instructors conventionally present in front of the students or use chalks to write on big blackboards. However, in recent years, many instructors have adopted various teaching styles and tools to ensure effective delivery (Hsieh, et al., 2011; Dissanayaka, 2024).

With experience, course instructors have been trying to design and implement several methods in their respective courses to help students progress toward many different learning goals and outcomes (Pintrich, 2004; Masek & Yamin, 2012). This effort challenges instructors to question how effective those methods are, how the outcomes can be effectively measured, and how these methods can be reviewed and redesigned.

Electromagnetic Theory Course in General

Electromagnetic theory (EMT) is one of the first-year core subjects in the electrical and electronics engineering program. At the end of the course, the students should be able to appreciate the basic concepts of the electromagnetic (EM) field in free space and material media and apply the fundamental laws and techniques used in calculating the EM field. Maxwell's equations are used to analyse the propagation of EM plane waves. Students are also expected to be able to explain and analyse transmission line response and use the Smith chart to determine load impedance, admittance, voltage standing wave ratio (VSWR), and other parameters associated with transmission line analysis. It involves explaining the electrostatic and magnetostatic fields and the time-varying (dynamic) EM field in free space and material media. With the help of calculus and vector calculus, the calculations of static and time-varying fields can be obtained and analysed. The EM wave propagation in free space and material media can be derived and analysed using Maxwell's equations. The media that EM waves propagate is known as a transmission line, and it can be microstrip, coax, waveguide, etc. It is not only quite challenging for students to digest the concepts quickly, but it also poses many challenges for instructors to plan and design the course effectively. Therefore, it is necessary to introduce a practical framework to formulate the new teaching methodology to enhance students' learning experience and attain the course learning outcomes.

High-frequency Electronic Design Automation in a Brief

There are several Electronic Design Automation (EDA) tools available nowadays. However, the tools are costly or complicated

for first-year students and instructors to utilise and comprehend fully. A good tool is not enough to improve the teaching style unless instructors are well-experienced and equipped with practical demonstration techniques. There is a need for an enhanced design framework that provides flexibility in designing courses and offers value to instructors as a communication tool, an analytical tool, and a design tool. In this paper, the use of technologies such as design and simulation tools to enhance teaching and learning has been briefly highlighted In combination with the proper framework, a meaningful and aspirational course can be achieved to provide insight and understanding of the subjects effectively, especially engineering core subjects. The example of implementing digital tools coupled with the goals framework has been reported in one core subject, EMT, in general, electrical and electronics engineering programs. It is followed by the EDA tool, which is designed and used for high-frequency circuit simulation. The embedded technique using the EDA tool to bridge the gap between the theoretical concept and practical demonstration is proposed in the next section. Lastly, the tool has demonstrated the state of the art of implementing the goals framework to achieve a high learning experience.

Besides software tools, graphical tools can be blended into course content to strengthen and highlight the crucial aspects of any topic. For example, Smith Chart, impedance, and admittance graph are widely used to characterise the performance of microwave transmissions and circuits. It was developed in 1939 by P.H. Smith as a graphical tool to analyse and design transmission-line circuits (Ulaby & Ravaioli, 2022). It was initially intended to facilitate calculations involving complex impedances. The general Smith Chart is shown in Figure 1. It consists of real circles, r_L, and imaginary circles, X_L, which are defined by the following equations,

$$\left(r_r - \frac{r_L}{1+r_L}\right)^2 + r_i^2 = \left(\frac{1}{1+}\right)^2$$

$$(r_r - 1)^2 + \left(r_i - \frac{1}{r_L}\right)^2 = \left(\frac{1}{r_L}\right)^2$$

Without this graphical tool, it is more challenging for students to understand transmission line theory fully. On top of this, using suitable software tools will further enhance the learning experience by applying theoretical concepts in practical use cases such as impedance matching circuits.

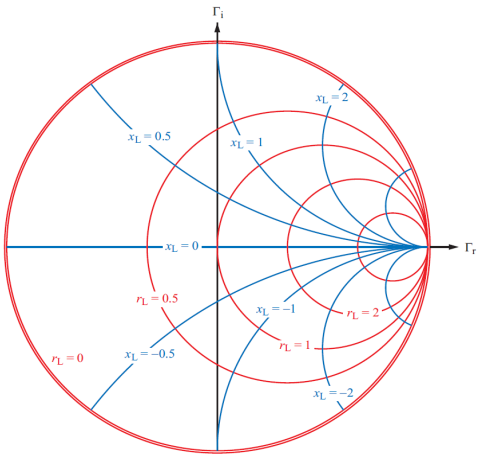


Figure 1 The Smith Chart

Implementing A Goals Framework in Teaching Style Methodology

A goals framework is a design tool that instructors can use in several ways: communicate within teaching teams or between instructors and students, analyse the existing course experiences, redesign the course, and create a new course experience (Stolk & Martello, 2018). Figure 2 depicts the goals framework that can be used to revise and reevaluate the existing course.

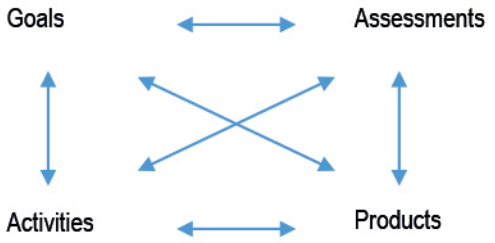


Figure 2 The goals framework to enhance the course

Figure 3 shows the proposed flow chart for implementing the above framework to reevaluate and enhance the EMT course teaching style. The flow chart is based on the transmission line and Smith Chart topic, which can help students fully understand the course concept.

In Phase 1, instructors need to set the goals for the course by answering the following questions.

1. What are the primary objectives/course learning outcomes for the course that you want the students to take away with them after the semester?
2. What are the main topics worth being familiar with?
3. What essential things do you want the students to know and do?
4. What concepts or math do you think are quite painful for students to endure and get through?

By answering these questions, instructors can better understand the course objectives and essential parts that are worth knowing and

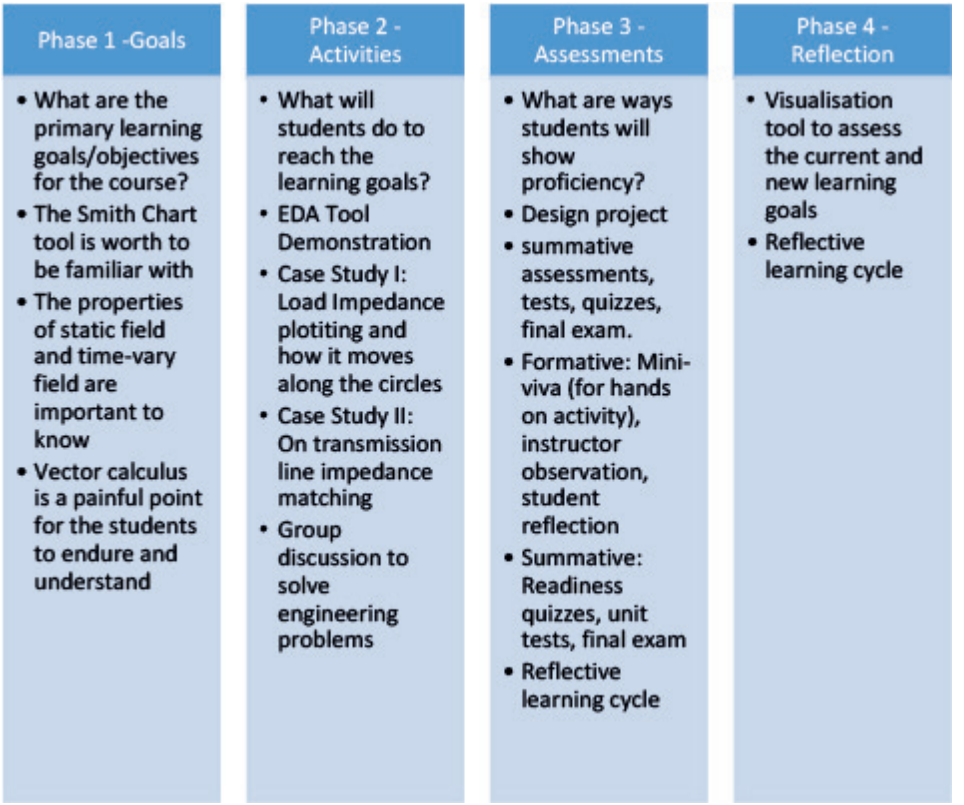


Figure 3 Proposed EMT course design flow

understanding. At the same time, instructors can understand the challenges that students are facing. This will lead to Phase 2, the design activities for the course. To fulfil and achieve the goals in Phase 1, the course lecturer should design several activities to help the students attain those essential goals and topics identified earlier. Some of the activities that can help to address these goals are:

1. To understand more about vector calculus, one of the tutorial students' pain points, more tutorial questions and homework in class practices together in groups or individually is fundamental to students.
2. Demonstrating the EDA tool can help students understand the concepts of electromagnetic waves and their applications. With the tool available, students can quickly grasp the transmission line characteristics and learn how to perform any necessary matching circuit.

In phase 3, the students are tested to determine whether they can attain the learning outcomes. Each of the goals comes together with the designed activities and results. By looking at each product from each goal, the instructor can determine which goals and activities this product can align with. Hence, the assessment can be formulated accordingly to suit the alignment. In this EMT course, the key outcomes include designing an antenna prototype using FEKO software, understanding electromagnetic waves and vector properties, and completing various assessments such as tests, quizzes, and lab viva examinations.

To complete the course revision and ensure that the course objectives are met and can be enhanced further, the complete set of visual tools (Stolk & Martello, 2018) shown in Figure 4 can help instructors compare the current goals with proposed new goals and weigh trade-offs associated the changes to the course

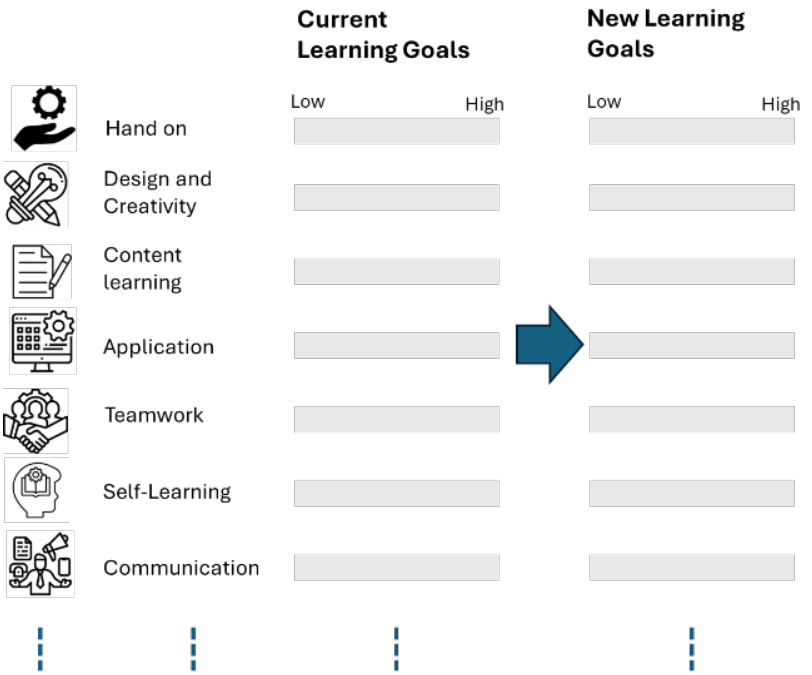


Figure 4 A sample visual tool for course revision

goal structure. This tool can be customised to accommodate any specific course requirements under revision.

This tool is not only used by instructors but can also be used as a communication tool to get students' views on the current course practice. After receiving the rating from both instructors and students, the course owner can revise the course learning objectives from time to time to ensure the effectiveness of delivering the topic and understand more about the students' learning experiences can be attained.

Conclusion

The teaching method using a goals framework coupled with EDA tools has been proposed as a communication tool between instructors or between students and instructors. An example of implementing this proposed teaching and learning method is applied to one topic of Electromagnetic theory, the Smith Chart. Instructors can always use the tool as a guideline to evaluate and redesign the course content. With the help of the goal framework and EDA tools, it is believed that the students' learning experience has improved.

References

Hsieh, S.-W., Jang, Y.-R., Hwang, G.-J., & Chen, N.-S. (2011). Effects of teaching and learning styles on students' reflection levels for ubiquitous learning. *Computers & Education,* 57(1), 1194–1201.

Dissanayaka, T. D. (2024).The learning styles and the preferred teaching-learning strategies of first-year Physiotherapy students, *International Journal of Scientific and Research Publication*, 4(7).

Pintrich, P. R. (2004). A Conceptual Framework for Assessing Motivation and Self-Regulated Learning in College Students. *Springer Nature Link*, 16(4), 385–407.

Stolk, J. D., & Martello, R. (2018). Reimagining and empowering the design of projects: A project-based learning goals framework, 2018 IEEE Frontiers in Education Conference (FIE), San Jose, United States of America, 2018, pp. 1-9, Doi:10.1109/FIE.2018.8658981.

Masek, A., & Yamin, S. (2012). The impact of instructional methods on Critical thinking: A comparison of problem-based Learning and conventional approach in Engineering education. *International Scholarly Research Notices,* 1, 759241.

Ulaby, F.T. & Ravaioli, U. (2022). *Fundamentals of Applied Electromagnetics,* Global Edition. Pearson Education Limited.

Effective Teaching Method with Integration of Slido and No-Hands App

Kamaluddeen Usman Danyaro*, Said Jadid AbdulKadir, Umar Danjuma Maiwada, and Shamsu Abdullahi
Universiti Teknologi PETRONAS, Malaysia.
*kamaluddeen.usman@utp.edu.my

Introduction

Integrating technology in education has revolutionised traditional teaching approaches, introducing tools that enhance student engagement, support inclusivity, and improve learning experiences. This study examines the effectiveness of Slido, a live polling, Q&A, and feedback tool, alongside the No-Hands App. This study is designed to facilitate equal classroom participation by eliminating the need for students to raise their hands. The combination of these tools addresses persistent challenges in traditional education methods, providing solutions that promote a more inclusive and participatory learning environment. Hence, this research examines how these tools can improve interaction and student engagement in online and offline classrooms. Also, the growing demand for hybrid learning solutions, a trend accelerated by global events such as the COVID-19 pandemic, has been addressed (Li et al., 2021).

Hybrid and entirely virtual learning models have quickly become essential, allowing flexibility in how, when, and where learning occurs. However, this flexibility has unique challenges, particularly in fostering interaction and ensuring equitable participation (Singh et al., 2022). Traditional classrooms rely on verbal participation; students are encouraged to raise their hands to engage in discussions or answer questions. Yet this method often results in unbalanced participation, as more outspoken or socially confident students tend to dominate, while quieter or introverted students remain disengaged (Faust, 2021). This imbalance creates learning gaps, as some students may feel overlooked or hesitant to participate actively. Slido and the No-Hands App have emerged as potential solutions to these challenges by offering students an anonymous and accessible platform to voice their thoughts, pose questions, and participate in class activities without fear of judgment.

The No-Hands App, for instance, facilitates equal participation by randomly selecting students to contribute during discussions, ensuring that every voice has a chance to be heard (Қатаев & Еркінқызы, 2021). This approach helps address the issue of unequal participation and makes classroom dynamics more balanced. Slido's live polling and Q&A functions allow students to respond to questions and engage in real time, promoting a more interactive learning experience. The anonymous nature of Slido provides students with the comfort of expressing themselves freely (Ha, 2018). Thus, this fosters a space where students who may hesitate to speak up feel more comfortable sharing their views. The study aims to explore how these technological tools can make a tangible difference in improving student engagement, particularly among students who are generally more reserved or less inclined to participate in traditional classroom settings.

Additionally, real-time feedback is another critical aspect that Slido and the No-Hands App address, allowing instructors to gauge student understanding more accurately (Smirnov, 2021). In traditional settings, it is often challenging for instructors to assess whether all students have grasped the content effectively. With real-time polling and Q&A sessions, instructors receive immediate feedback on student comprehension. Similarly, this enables them to adapt to their teaching methods or revisit complex topics as needed. In hybrid and online classrooms, where physical interaction is limited, these tools prove even more valuable, helping instructors maintain an interactive and responsive environment.

As educational institutions continue to embrace hybrid learning models, there is a pressing need to evaluate and integrate tools that bridge the gap between virtual and physical classrooms. This study assesses the impact of integrating Slido and the No-Hands App on student engagement and participation, particularly in hybrid settings where traditional engagement methods may not be as effective (Haritos, 2019). The study also seeks to provide educators with insights into best practices for incorporating these tools. Likewise, this helps them optimise their teaching strategies to benefit students and instructors.

Moreover, the study highlights the broader implications of using these tools for inclusivity. When implemented effectively, Slido and the No-Hands App can help create a learning environment where all students, regardless of personality type or confidence level, feel encouraged to contribute. This can lead to a more equitable learning experience, allowing students to engage actively and benefit equally from class discussions. Typically, addressing the limitations of traditional classroom dynamics, the integration of Slido and the No-Hands App offers promising directions for more inclusive and interactive education in diverse learning environments.

Literature Review

Technology adoption in education has skyrocketed, prompted by the need to address various learning challenges and the increasing prevalence of hybrid and online learning models. This reviews technology-enhanced teaching methods, focusing on digital engagement and inclusivity tools. Thus, Slido and the No-Hands App examine technology's broader impacts on student participation, real-time feedback, and inclusivity in educational settings.

Although research in this area is limited, several notable studies have emerged. For instance, Shetty and Ghanat investigate the effectiveness of Slido in an engineering classroom by surveying 49 engineering students about their experiences (Shetty & Ghanat, 2020). The findings reveal strong positive responses, with students appreciating Slido's anonymity, its capacity to enhance engagement, and the immediacy of feedback it provides. While the study highlights Slido's potential to improve learning, it also notes limitations, such as possible distractions and the need for further research into its long-term impact on learning outcomes. Similarly, Adebola (2024) evaluates Slido's effectiveness in promoting active learning within a South African university classroom, addressing the challenges posed by traditional lecture-based teaching in resource-limited environments. The study uses action research within a transformative paradigm to evaluate how Slido's features (live polls, quizzes, and anonymous Q&A) impact student participation. The results show that Slido significantly boosts engagement, particularly from students who are reluctant to talk, indicating that it can potentially promote interactive learning. The study concludes that Slido can be a valuable tool for encouraging active learning in remote institutions if given the right tools and instruction. In a similar study, Muthmainnah (2019) explores the application of Slido to enhance student engagement in a grammar class at an Indonesian university. The

study employed a classroom action research methodology across two cycles. The research assessed whether Slido could improve student participation and understanding of grammar. The results indicate a significant increase in scores and engagement, demonstrating that Slido effectively boosts involvement in the class. The study concludes that Slido is a valuable tool for enhancing student learning by reducing the fear of public participation and fostering a dynamic classroom environment.

Additionally, Ningsih investigates the impact of Slido on student engagement and learning outcomes in English for Specific Purposes (ESP) courses (Ningsih, 2023). The study combines quantitative data from questionnaires with qualitative insights from open-ended questions. Findings indicate that students view Slido positively, noting its effectiveness in enhancing understanding, boosting motivation, and creating a more enjoyable learning experience. Zulfa and Laras's research examines the effectiveness of online platforms for distance learning in Indonesia during COVID-19, explicitly focusing on integrating Schoology and Slido (Zulfa & Laras, 2020). Using a descriptive qualitative approach, the study surveyed 120 teachers across various educational levels in Indonesia. The findings reveal that Google Classroom and WhatsApp Group were the most widely used platforms. The research highlights the need for teacher training to effectively use interactive tools like Schoology and Slido, which provide course management, polling, and Q&A features.

Additionally, Stojaković's study demonstrates that Slido effectively enhances student engagement in physical and online learning settings (Stojaković, 2022). Slido addresses the challenge of maintaining student interest as an affordable and interactive tool, especially in increased online learning following the pandemic. A case study of 181 students found that Slido significantly boosted engagement compared to traditional lectures, highlighting its effectiveness for interactive learning. The Duarte study outlines the benefits of using Slido to enhance interactivity in virtual learning environments. It introduces Slido as a versatile tool to address the challenges of online teaching, especially during the COVID-19 pandemic when reliance on Zoom increased and Zoom's built-in polling features proved limited. The study highlights Slido's advantages over Zoom's polling functionality, including its support for hybrid teaching contexts, a wider range of polling options, and the ability to integrate images into polls. The article aims to guide teachers in using Slido to create a more interactive and engaging online learning experience for students.

The role of technology in fostering student engagement has been extensively studied, with evidence suggesting that interactive tools like live polling and Q&A applications can significantly improve classroom participation (Ko, 2023). These tools address common barriers to engagement, such as the reluctance to speak in class, by allowing students to interact anonymously. Slido, for instance, is widely recognised for its effectiveness in enhancing student engagement by enabling anonymous participation through live polls and Q&A sessions, allowing students to voice questions and thoughts they might hesitate to share openly (Escalaw et al., 2023). This capability is especially beneficial in hybrid learning environments where some students may feel disconnected or intimidated in virtual settings. Such studies underline the potential of digital tools to create an inclusive, comfortable atmosphere that facilitates active participation.
Traditional classroom participation methods often prioritise verbal responses, which can inadvertently favour more outspoken students, leading to an uneven distribution of participation and engagement. Research by Sacco (2021) suggests that these conventional methods can create a learning gap, as students who are more introverted or hesitant to speak may feel disengaged or overlooked. The No-Hands App addresses this gap by randomly selecting students to participate, thereby levelling the playing field and reducing bias. Such apps,

designed to ensure equitable participation, also reduce the pressure of voluntary participation and prevent dominant voices from overshadowing quieter ones (McGraw, 2022). These findings highlight the limitations of traditional participation techniques, especially in environments that aim for inclusivity and balanced engagement.

The shift to hybrid and virtual learning, accelerated by the COVID-19 pandemic, has highlighted the importance of digital tools in fostering inclusivity. Studies (Pires & Sousa, 2022) found that hybrid classrooms often struggle with engagement and inclusivity due to the lack of physical presence, which makes it difficult for instructors to monitor student understanding. Real-time polling and Q&A tools, such as Slido, mitigate these challenges by providing instant feedback that instructors can use to gauge student comprehension and adjust their teaching accordingly. Such tools encourage quieter students to participate without fear of being judged, thus promoting a more inclusive learning environment (Xiong et al., 2024). Significantly, the No-Hands App's randomised selection feature further promotes inclusivity by ensuring that all students, regardless of their confidence levels or social inclinations, have an equal opportunity to contribute. This mechanism improves participation and diversifies classroom discussions, fostering a more collaborative and inclusive environment that benefits all learners (Ko, 2023). These tools' alignment with inclusive teaching practices underscores their relevance in today's hybrid educational landscape.

Real-time feedback has been identified as a critical component of effective learning, allowing instructors to immediately address areas where students struggle (Adebola, 2024). Digital tools like Slido facilitate this by offering instant feedback through live polls, enabling instructors to adjust their teaching strategies in response to student comprehension levels. Studies by Ningsih (2023) reveal that this immediate feedback mechanism improves student engagement and enhances learning outcomes by helping students identify and address their knowledge gaps during the lesson. Likewise, by making student feedback more accessible and actionable, such tools enable a more responsive teaching approach that adapts to student needs in real time.

Research comparing digital engagement tools in traditional versus hybrid classrooms suggests that these tools may have a more pronounced impact in virtual or hybrid environments where physical presence is limited (Muthmainnah, 2019). In a study by Rumbley et al. (2021) and Smirnov (2021), hybrid classrooms utilising tools like Slido and the No-Hands App reported significantly higher student participation and inclusivity than those without such tools. The study attributes this increase to the enhanced accessibility of digital tools, which enable students to engage both in-person and remotely. Similarly, the randomised participation feature of the No-Hands App was found to promote inclusivity by reducing the need for physical hand-raising. This makes it an ideal solution for hybrid classrooms, where traditional participation methods may be less effective.

While substantial evidence supports the use of digital tools like Slido and the No-Hands App for improving engagement and inclusivity, certain limitations have been noted. For instance, these tools require technological proficiency from both instructors and students, which may present a barrier in some educational contexts (Shetty & Ghanat, 2020). Additionally, long-term studies are needed to evaluate the sustained impact of these tools on learning outcomes, as most existing research focuses on short-term effects. There is a need to explore the integration of advanced technologies, such as AI-driven analytics, to personalise feedback further and enhance participation (Sampath et al., 2022). Moreover, expanding studies across diverse educational contexts and subject areas will provide a more comprehensive understanding of these tools' potential.

Finally, digital tools like Slido and the No-Hands App must effectively promote student engagement, inclusivity, and real-time feedback. These tools address the limitations of traditional participation methods, particularly in hybrid and virtual learning environments, where fostering an interactive and inclusive atmosphere is challenging. While promising, optimising these tools for long-term use, enhancing scalability, and evaluating their impact on diverse educational settings is necessary.

Research Methodology

This study utilised a mixed-methods approach to investigate the effectiveness of integrating Slido and the No-Hands App in enhancing student participation, inclusivity, and engagement in online and offline classroom settings, as seen in Figure 1. The methodology was designed to assess the impact of these tools on various aspects of the learning experience, including student interaction, real-time feedback, and instructional adaptation. The following subheadings describe the participant selection, data collection tools, procedures, and data analysis techniques.

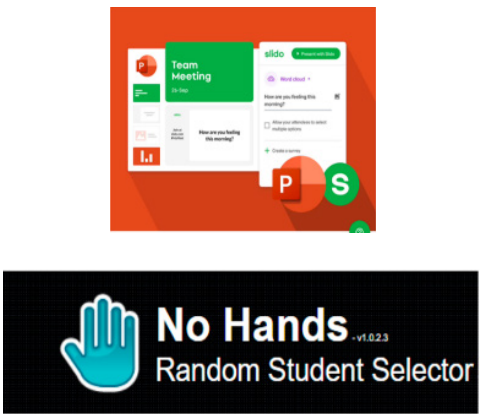


Figure 1 The method with Integration of Slido and No-Hands App

Participants

The participants in this study included undergraduate students from diverse disciplines enrolled in hybrid courses at the university. Fifty students and three instructors were selected, with students randomly assigned to control and experimental groups. The control group participated in classes using traditional hand-raising and verbal interaction methods, while the experimental group utilised Slido and the No-Hands App for classroom interactions. The selection criteria ensured that participants represented a range of academic backgrounds and participation tendencies, from highly active to more reserved students, providing a balanced sample for evaluating the tools' impact.

Data Collection Tools

In gathering comprehensive data, the study employed both quantitative and qualitative data collection methods:

Pre- and Post-Study Surveys

Surveys were distributed to students and instructors in both groups before and after the study. The surveys assessed participants' attitudes towards classroom participation, comfort with the participation tools, and perceptions of inclusivity and engagement. The post-study survey also collected participants' satisfaction with their classroom experience.

Classroom Participation Metrics

Participation frequency and quality data were collected through classroom recordings, attendance logs, and participation tracking using Slido and the No-Hands App. Participation metrics were compared between the control and experimental groups, including the number of questions, the answers provided, and the number of students actively participating.

Focus Group Interviews

Focus group interviews were conducted with a subset of students and instructors from the experimental group to gather in-depth feedback on their experiences using Slido and the No-Hands App. The discussions provided qualitative insights into students' and instructors' perceived benefits, challenges, and overall satisfaction with these tools.

Instructor Observations and Feedback Forms

Instructors were asked to complete feedback forms on their experiences and observations with the integration of the tools. This allowed for an assessment of how Slido and the No-Hands App influenced teaching practices, the ability to track student comprehension and the overall ease of implementation in a hybrid learning environment.

Procedure

The study was conducted over one semester with the following procedure,

Orientation Session

An orientation session introduced instructors and students to the features of Slido and the No-Hands App, ensuring they were comfortable using the tools in class.

Implementation in Classrooms

Instructors in the experimental group integrated Slido for live polling, Q&A sessions, and real-time feedback, while the No-Hands App was used to ensure randomised and equitable participation during discussions. Traditional teaching methods were maintained in the control group for comparison.

Data Collection Points

Participation data, survey responses and observational data were collected regularly throughout the semester. The pre-study surveys were completed in the first week, while post-study surveys and focus group interviews took place in the final week of the study.

Data Analysis

The collected data were analysed using quantitative and qualitative methods to evaluate the effectiveness of Slido and the No-Hands App on student engagement and participation:

Quantitative Analysis.

Survey responses, participation frequency, and attendance data were statistically analysed using descriptive and inferential statistics. T-tests and ANOVA tests were performed to identify significant differences in engagement levels and participation frequency between the control and experimental groups. The analysis also examined whether introducing these tools led to a measurable increase in participation from typically less vocal students.

Qualitative Analysis

Focus group interviews and open-ended survey responses were coded thematically to identify recurring themes related to student and instructor experiences. These qualitative insights supported quantitative findings, offering context on how the tools impacted students' comfort with participation, instructors' ability to gauge comprehension, and the overall classroom dynamic.

Comparison of Hybrid vs. In-Person Settings

For hybrid classes, participation trends were analysed separately to assess the impact of the

tools in online versus offline environments. This analysis aimed to determine if Slido and the No-Hands App had a comparable effect on engagement in both settings, given the challenges of fostering interactivity in virtual classrooms.

Ethical Considerations

Informed consent was obtained from all participants before data collection, and anonymity was assured in survey responses, interviews, and participation data. The study also adhered to institutional guidelines for the ethical treatment of participants, with particular attention to maintaining data confidentiality and minimising disruptions to the learning experience.

Result and Discussions

This study's results suggest that integrating Slido and the No-Hands App into classroom settings substantially improved student engagement, inclusivity, and instructor effectiveness across hybrid and traditional teaching environments. These tools demonstrated specific benefits in enhancing student participation, particularly among students who typically refrain from contributing in conventional settings. Similarly, the anonymous nature of Slido allowed students to participate in polls, ask questions, and give feedback without the fear of judgment or peer pressure, as seen in Figure 2. Data collected from Slido usage showed a notable increase in the frequency of student questions and responses, with students previously identified as more introverted or hesitant displaying higher engagement. Similarly, the No-Hands App contributed to equalising participation by randomly selecting students to speak, ensuring that all voices were heard rather than relying on the traditional hand-raising method, which can marginalise fewer vocal students. This randomised selection mechanism encouraged students to stay attentive and involved, as they recognised that they would be expected to contribute at any point. Also, student feedback further emphasised that these tools included them in the classroom dialogue and reduced the intimidation factor often associated with public speaking. This aligns with the study's objective to create a more inclusive learning environment, providing students with equal opportunities to participate, ultimately leading to a more dynamic and balanced classroom atmosphere. Hence, using Slido gave instructors real-time insights into student comprehension and engagement levels. Through live polling and Q&A sessions, instructors quickly identify areas where students struggle and adjust their teaching approach accordingly. This adaptability proved particularly valuable in hybrid and online settings, where traditional physical cues of understanding (e.g., body language) are less observable. Instructors reported that the immediate feedback allowed them to focus on problem areas, clarify misconceptions, and make lessons more responsive to student needs.

Furthermore, instructors noted that they were able to track participation trends, which helped identify students who may require additional support. For example, students who consistently refrained from participating, even with the anonymity of Slido, have been given extra support or encouraged through other means. This enhanced feedback loop allowed instructors to create more personalised learning experiences, benefiting students who may be overlooked in a traditional classroom setting. Typically, survey data revealed a strong student preference for the interactive approach enabled by Slido and the No-Hands App over conventional methods. Most students felt more comfortable contributing to class discussions without the pressure of raising their hands, citing the benefits of anonymity and reduced anxiety. This key finding highlights how digital tools can help bridge the engagement gap between extroverted and introverted students. Thus, this fosters a more balanced learning environment where all students feel empowered to participate. Likewise, students also reported

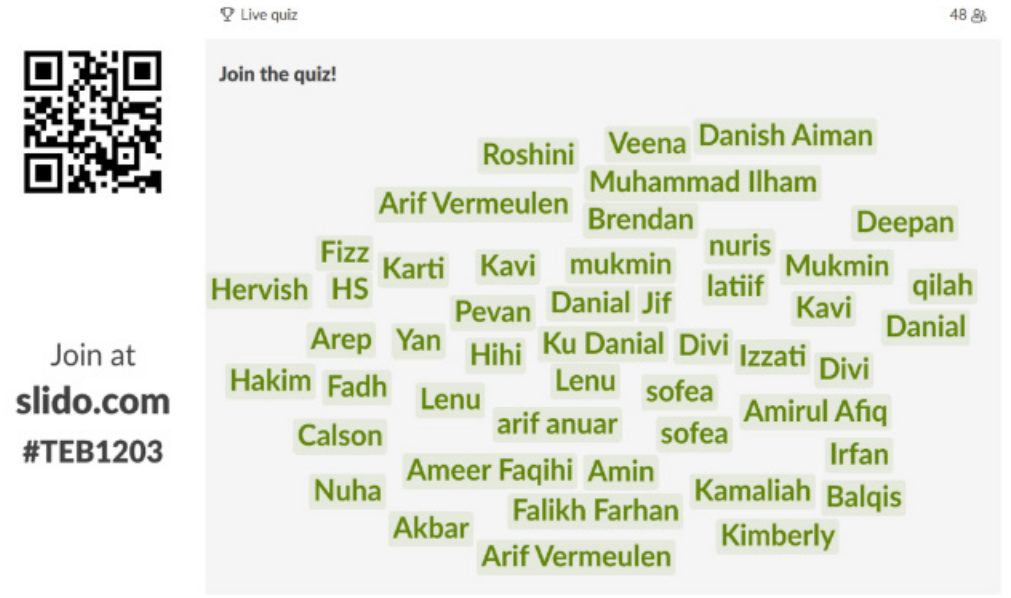


Figure 2 Student members

higher satisfaction levels, particularly in hybrid and online classrooms, where physical interaction is limited. The digital tools offered an opportunity to engage actively, reinforcing the sense of community and collaboration, which is often lacking in virtual environments. These findings suggest that integrating Slido and the No-hands App can positively impact student morale and participation. This ultimately contributes to a more enjoyable and practical learning experience. Finally, the study's findings underscore the importance of integrating technological tools in hybrid and online learning environments, where student engagement often declines due to the lack of physical interaction. Slido and the No-hands App provided solutions to these issues, allowing instructors to maintain interactive and engaging lessons regardless of the classroom format. The tools also encouraged continuous engagement and active participation in hybrid settings. Thus, it addresses the common challenge of student disengagement in virtual contexts.

The results of this study support the idea that digital tools like Slido and the No-hands App are practical in increasing student engagement, fostering inclusivity, and providing instructors with actionable feedback. The increased participation observed through these tools reflects a shift toward a more inclusive learning experience that benefits extroverted and introverted students. Furthermore, offering anonymous contributions through Slido enabled more students to engage openly, reducing the performance pressure often associated with traditional classroom participation. However, while the results are promising, it is essential to consider the potential limitations and areas for further exploration. For instance, while Slido and the No-hands App effectively increased participation, long-term impacts on academic performance and learning outcomes were not assessed.

Conclusion

The integration of Slido and the No-Hands App has shown promising results in enhancing student engagement, inclusivity, and participation in both online and hybrid educational settings. Although fostering anonymous and equitable participation, these tools address key limitations in traditional teaching, such as unequal student involvement and limited real-time feedback. Slido's live polling and Q&A features empower students to communicate openly, while the No-Hands App ensures balanced participation, giving all students a voice in class discussions. Instructors benefit from immediate feedback on student comprehension, allowing them to adapt their teaching strategies and create a more responsive learning environment.

Future research could address this by conducting longitudinal studies to measure whether the sustained use of these tools leads to improved grades, comprehension, and material retention over time. Additionally, while this study focused on hybrid and online learning environments, it would be beneficial to assess the scalability of these tools across different age groups, subject areas, and educational institutions. Integrating additional technologies, such as AI-driven analytics, could further personalise the learning experience by providing deeper insights into student performance and engagement trends. The integration of Slido and the No-Hands App offers a feasible and practical approach to addressing the limitations of traditional teaching methods, particularly in hybrid and online settings. These tools increase student engagement and inclusivity and provide instructors with immediate feedback that can be used to tailor instruction dynamically. This study highlights the potential of digital tools to create an inclusive and collaborative classroom environment, which is especially crucial in hybrid models that have become more prevalent. While the initial findings are promising, further research is essential to understand the long-term impact of these tools on student outcomes and academic performance. Future studies could explore the role of AI-driven analytics in enhancing feedback and the scalability of these methods across different subjects and age groups. Ultimately, using Slido and the No-Hands App demonstrates a significant step toward a more dynamic, inclusive, and engaging educational experience that benefits students and educators alike.

References

Adebola, O. O. (2024). The dynamics of Slido to promote learning in rural university classrooms. *Research in Social Sciences and Technology*, *9*(3), 122-139.

Escalaw, M. A., Ambat, E. J. C. T., De Leon, M. M., & Orlinga, E. B. (2023). The effects of an integrated STEM education approach for online learners in Grade 10 Mathematics: A Research Study. *Asian Journal of STEM Education*, *3*(2), 74-93.

Faust, R. (2021). Group work at the college level: a case study. Master's Thesis, Department of Educational Technology, Concordia University, Montreal.

Ha, J. (2018). Using mobile-based Slido for effective management of a university English reading class. *Multimedia-Assisted Language Learning*, *21*(4), 37.

Haritos, N. (2019). Hands-on experiential learning of structural mechanics. *Australian Journal of Structural Engineering*, *20*(4), 259-270.

Ko, B. (2023). Comparing the effects of traditional, VR, and custom-made input devices on usability, cognitive load, and presence on virtual laparoscopy tasks. Master's Thesis, Institute of Technology, University of Ontario, Ontario.

Li, Q., Li, Z., & Han, J. (2021). A hybrid learning pedagogy for surmounting the challenges of the COVID-19 pandemic in performing arts education. *Education and Information Technologies, 26*(6), 7635-7655.

McGraw, T. (2022). Implementation of high-quality course design in online education. Dissertation, Prescott College, Prescott, Arizona.

Muthmainnah, N. (2019). An effort to improve students' activeness in structure class using Slido app. *Journal of English Educators Society*, *4*(1), 1-7.

Ningsih, F. (2023). Uncovering students' perceptions of Slido: an innovative engagement with real-time interactive technology in ESP. *Issues In Applied Linguistics & Language Teaching*, *5*(1), 7-17.

Pires, C., & Sousa, M. J. (2022). E-learning methodologies involving healthcare students during COVID-2019 Pandemic: A systematic review. *Proceedings of International Conference on Information Technology and Applications: ICITA 2021*, New York: Springer.

Sacco, K. (2021). The impact of STEM integration on the engagement of struggling learners. Master's Thesis. Department of Teaching, Learning and Technology: Hofstra University, New York.

Sampath, V., Arasan, G., & Edison.K, T. A. (2022). online learning: ICT-Based tools for interaction and effectiveness. *ECS Transactions*, *107*(1), 10277–10284.

Shetty, N. H., & Ghanat, S. (2020). Slido as a student response system in engineering education. 2020 ASEE Southeastern Section Conference, Washington: American Society of Engineering Education.

Singh, J., Evans, E., Reed, A., Karch, L., Qualey, K., Singh, L., & Wiersma, H. (2022). Online, hybrid, and face-to-face learning through the eyes of faculty, students, administrators, and instructional designers: Lessons learned and directions for the post-vaccine and post-pandemic/COVID-19 world. *Journal of Educational Technology Systems*, *50*(3), 301-326.

Smirnov, A. (2021). *Hand Tracking for Mobile Virtual Reality,* https://www.youtube.com/watch?v=tkScdspnMk0.

Xiong, W., Zhang, F., Qu, S., Yin, L., Li, K., & Huang, Y. (2024). Marangoni-driven deterministic formation of softer, hollow microstructures for sensitivity-enhanced tactile system. *Nature Communications*, *15*(1), 5596.

Qatayev, N., & Erkinkyzy, A. (2021). Effectiveness of digital educational technologies in the organisation of the learning process. *Bulletin of Kazakh National University. Series of Pedagogical Sciences*, *67*(2), 71-80.

Duarte, S. (2024). How professional development supports curriculum implementation. In *Advances in Educational Marketing, Administration and Leadership Book Series*, (264-274), Hershey: IGP Global. Doi:10.4018/978-1-6684-9904-7.ch017.

Stojaković, D. (2022). Modern learning improvements supported by IT Solutions-Slido case study for better engagement. *Annals of Spiru Haret University. Economic Series*, *22*(2), 29-37.

Zulfa, V., & Laras, P. (2020). Schoology and slido: the perfect platform combination for distance learning during the covid-19 pandemic. *Proceedings of International Joint Conference on Science and Engineering (IJCSE 2020),* Dordrecht: Atlantis Press.

Integrating Virtual Reality for Enhancing Students' Understanding in Circuit Theory Education

Micheal Drieberg*, Azrina Abd Aziz, Khairul Nisak Md Hasan, Patrick Sebastian, Lo Hai Hiung
Universiti Teknologi PETRONAS, Malaysia.
*mdrieberg@utp.edu.my

Introduction

Circuit theory is one of the most essential and fundamental in Electrical and Electronics Engineering courses. However, many students struggle to understand the workings of a complex circuit comprising multiple voltage/current sources and circuit elements such as resistors, capacitors, and inductors. The student must determine parameters such as voltage drops, current flows, and power dissipation for any specified circuit. These are abstract parameters and cannot be seen physically, even in the laboratory. Furthermore, traditional teaching methods, often reliant on static diagrams and mathematical formulations, may fail to fully engage students or convey the practical applications of circuit concepts.

On the other hand, the integration of virtual reality (VR) technology in education has gained significant attention in recent years. Several studies have explored the effectiveness of VR-based learning environments across various disciplines (Kamińska, 2019). Research demonstrated the potential of immersive VR environments for enhancing spatial understanding and problem-solving skills (Araiza-Alba, 2021). Similarly, researchers highlighted the benefits of VR simulations in promoting active learning and engagement among students (Adi Badiozaman et al., 2022). Studies have shown that VR simulations can improve student comprehension and retention of complex abstract concepts by providing immersive learning experiences.

Therefore, this study aims to integrate VR to address the gap in traditional teaching methods for circuit theory education. The anticipated benefits of visualising abstract concepts and receiving real-time feedback in VR environments are expected to enhance the students' understanding and appreciation of the foundational course.

Literature Review

VR has emerged as a transformative tool in engineering education, offering immersive and interactive learning experiences. This technology enables students to visualise complex electronic circuits and their parameters in three dimensions, enhancing their understanding of theoretical concepts and practical applications.

Recent studies underscore the impact of VR on engineering education. Asham, Bakr, and Emadi (2023) comprehensively reviewed VR applications in electrical engineering education. They found that most works reported significant improvement in understanding complex concepts, making difficult concepts more tangible and accessible. Apart from that, other

advantages of VR include its attractiveness in capturing the interest and engagement of the new generation of digitally native students.

VR was implemented with 3-D prototyping in project-based learning (PBL) for engineering education (Halabi, 2020). This was based on their application and effectiveness in industries for product design and user experience assessment. The study shows VR's positive impact on teamwork, engagement, retention, and motivation. They concluded that VR in engineering education can significantly improve students' achievements, course outcomes, communication, and problem-solving skills.

The scholarly literature on VR-based learning environments provides valuable insights into the potential impact of VR-based modules. Constructivism, the predominant learning theory referenced, emphasises that learners actively construct knowledge based on prior experiences (Marougkas, 2023). VR technology facilitates constructivist learning by immersing students in interactive environments conducive to exploration and experimentation. By leveraging immersive visualisation, interactivity, and constructivist learning theory, VR technology has the potential to transform traditional teaching methods and enhance student learning outcomes in circuit theory education.

Nevertheless, further research is needed to explore the specific pedagogical approaches and design considerations that optimise the effectiveness of VR-based modules in facilitating application and visualisation in circuit theory education. In conclusion, the integration of VR in circuit theory education holds significant potential for enhancing conceptual understanding, promoting accessibility, and improving student achievements.

Research Methodology

Developing VR-based modules tailored to circuit theory involves incorporating accurate circuit simulations and interactive visualisation elements. These modules are designed to provide scaffolded activities before and after the VR sessions, aligned with the Course Learning Outcomes (CLO). In the VR environment, students will engage in learning activities focused on Kirchoff's current and voltage laws. The VR of a simple circuit will be first developed to familiarise the students with the VR environment. The students are encouraged to interact within the VR with the parameters such as voltage levels and resistor values and see how they impact the circuit's behaviour regarding the voltages and currents.

Next, the VR of a complex circuit will be developed, with complexity matching those seen in the course that are usually solved using mathematical equations. Here, students will gain a better understanding when they have an immersive experience of seeing how the equations are formulated in the VR environment. They will also understand how these equations correspond to the actual circuit behaviour as it interact within the VR environment.

Student performance and feedback will be evaluated through assessments and surveys. Pre-quizzes and post-quizzes will measure the improvement in students' understanding of circuit theory concepts. Statistical analysis can be utilised to determine if VR leads to significant learning gains when compared to traditional methods. Pre-surveys and post-surveys will gather data on students' attitudes and perceptions before and after using the VR modules. The survey feedback can be analysed to confirm if VR helped clarify abstract concepts such as Kirchhoff's laws, voltage drops, and current flows. Additionally, student reflections and observations will provide qualitative insights into the learning experience and the effectiveness of the VR modules.

Expected Result

The anticipated outcomes of this research are an enhancement in motivation, engagement, and student learning results in circuit theory education. The knowledge and insights acquired from this study will be gathered and disseminated among the practitioner community. This will encourage its application in other courses and stimulate the broader adoption of this cutting-edge technology.

Currently, this study is still in the preliminary phase. The initial drafts of the VR storyboard and concept of the circuit VR have been completed. The development of the actual VR environments and surveys/assessments are currently ongoing.

Conclusion

Many students undertaking the circuit theory course find it challenging to fully understand complex circuits due to the abstract nature of these concepts and the limitations of traditional teaching methods that rely on static diagrams and mathematical formulations. This study explores the potential of VR in enhancing circuit theory education.VR can transform traditional teaching methods by providing immersive and interactive learning experiences, making complex concepts more tangible and accessible. It aims to show that adopting VR can improve students' understanding and engagement in a highly immersive environment. As VR technology evolves, its role in engineering education will likely expand, offering even more innovative and compelling learning experiences.

Acknowledgement

This research is supported by the UTP Scholarship of Teaching and Learning (SoTL) grant 015LF0-073.

References

Adi Badiozaman, I. F., Segar, A. R., & Hii, J. (2022). A pilot evaluation of technology-enabled active learning through hybrid augmented and virtual reality app. *Innovations in Education and Teaching International,* 59(5), 586–596.

Araiza-Alba, P., Keane, T., Chen, W. S., & Kaufman, J. (2021). Immersive virtual reality as a tool to learn problem solving skills. *Computers & Education*, 164, 104121.

Asham, Y., Bakr, M. H., & Emadi, A. (2023). Applications of augmented and virtual reality in electrical engineering education: A review. IEEE, 11, 134717–134738

Halabi, O. (2020). Immersive virtual reality to enforce teaching in engineering education. *Multimedia Tools and Applications,* 79(5), 2987–3004.

Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R. E., Avots, E., Helmi, A., Ozcinar, C., & Anbarjafari, G. (2019). Virtual reality and its applications in education: Survey. *Information*, 10(10), 318.

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual reality in education: A review of learning theories, approaches, and methodologies for the last decade. *Electronics,* 12(13), 2832.

Incorporating Non-Fungible Tokens (NFTs) in Teaching and Learning (T&L) Activities

Yee Ho Chai*, Man Kee Lam, Thiam Leng Chew
[1]Universiti Teknologi PETRONAS, Malaysia.
*yeeho.chai@utp.edu.my

Introduction

In the era of digitalization, the applications of digital tools in teaching and learning activities have seen tremendous growth in the education sector. Without a doubt, the rippling effects of the COVID-19 pandemic continue to play a crucial role in driving digitalization applications in education. Digital platforms such as Microsoft Teams and Zoom have normalized cultural trends and behaviours in preparation for more sustainable teaching and learning activities.

In this context, the rise of digitalization has purported the lack of ownership by educators and students without physical interactions and the need to complement it with a comprehensive and reliable learning management system. Furthermore, falsifications of credentials and qualifications via digital technology are increasing, which is a worrying trend. Therefore, despite the increasing implementation of digital tools for educators and learners, the efficacy of traditional education and learning systems is debatable in the current decade.

Adaptation of blockchain in education sectors is still in its infancy. Although institutions have mainly utilized blockchain for academic records and credential validations, the applications of blockchain-based assets such as non-fungible tokens could drive toward a more sustainable teaching and learning process. This paper aims to discuss the potential applications of non-fungible tokens in driving toward efficient and sustainable teaching and learning activities in the era of digitalization.

Teaching and Learning Theory & Framework
Non-fungible tokens (NFTs) are primarily defined as unique digital assets with identifiers associated with the blockchain (Chevet, 2018). In general, blockchain is a decentralized, distributed, and public digital ledger that records transactions or digital information that cannot be altered or destroyed without leaving a specific footprint. Furthermore, the immutability of blockchain ensures all digital records are not misplaced or lost easily. This allows transparency and accountability in the mode of operations in the education sector moving forward.

While NFTs and conventional verifiable credentials hold unique identities digitally, the former is tamper-proof as NFTs are built on top of blockchains. Conventional verifiable credentials link key infrastructures with three entities: the issuer, the holder, and the credential verifier. In essence, a "bad actor" within the entities allows the exploitation of unwanted intentions (Cornelius, 2021). For example, a practical application of NFTs enables the verification of micro-credentials as a form of certification where users can verify publicly available information in the blockchain domain. NFTs are digital assets with multiple use

cases that expand beyond storing records and credentials only. Incorporation of a specific blockchain protocol, namely Proof of Attendance Protocol (POAP), in the form of NFTs as a form of collectables can potentially drive teaching and learning experiences further. POAPs are made of smart contracts that can be "minted" (created) through custom-made NFTs that align with the organizations' aspirations. In another context, POAP NFTs can also be used to prove the attendance of educators and students, which cater to specific real-world and virtual events and are recorded cryptographically. The use cases of POAPs can also be further expanded towards awards and recognition use cases in the education sector. Recognition of educator and student performances via arts or ornaments in the form of NFT using their metadata can motivate the receivers further.

The use cases of NFTs can be further expanded for their use cases to provide utility purposes such as scholarship entitlements to students. By linking the applications of POAPs, the verifier can ensure authentic information and actions have been achieved to receive POAP. In another context, the collected POAP symbolizes the entitlement or fulfilment of the student eligible for scholarship entitlements. Although the applications of NFTs are not widely applied in the education sector yet, nevertheless the versatility of NFTs as a unique digital asset can cater to other applications in the domains of patents, innovations and research, licensing and intellectual property as well as the university's educational curriculum in the education sector (Bamakan et al., 2022).

Research Methodology

A preliminary survey should be conducted to highlight the stakeholders in the education sector, mainly educators and students, on the potential implementation of NFTs and blockchain technologies in their curricular activities. The survey will take place in two phases, where a research-based and case-based interview will be conducted.

A research-based interview provides the participants with general questions about blockchain technology and NFT. The interview questions will be set up to gauge the participants' understanding of the technology. A case-based interview is a specific tailor-made case study revolving around the application of blockchain and NFT in the academic industry. The interview will gauge the requirements of blockchain applications in teaching and learning activities and other domains within the educational sector.

The interviews will be conducted with academic staff and students. A sample population of 20 lecturers, from junior to professors, will be interviewed by academic staff to ensure that distributed responses are obtained. For student interviews, a sample population of 100 students is targeted for students from Year 1 to Year 4. The students' responses are critical as they reflect the younger generation's understanding of blockchain and NFT.

The outcome of the preliminary survey provides a platform for a greater understanding of the implementation approach to enable the adaptation of blockchain technology and NFT in digitalized innovating teaching technologies such as VR/AR, MOOCS, metaverses, and so forth as its end objective.

Result and Discussions

The title appears near the top of the first page, centred. Authors' names, affiliations, complete addresses, and corresponding author's email addresses should appear right below the paper's title. The corresponding author's name should be marked with an asterisk (*) at the end of the name. Integrating NFT and blockchain technology has advantages for the education system, providing an indisputable digital record of ownership of a digital asset that can be used for various applications. The use cases of NFTs counter certification forgeries with the transparent information stored in

the blockchain. Furthermore, streamlining the verification process saves time and costs, especially when verifying academic records by both the student and institutions.

In addition, NFTs provide specific use cases that can be tailored to drive community-driven entities that are aligned with the organization's goals. Educators and students take ownership of the university's teaching and learning activities in this context. With the rise of metaverses in the industry, NFTs provide a unique identifier that can be expanded towards the untapped potentials in teaching and learning domains, especially for online university curriculums (Jeon, 2021).

Conclusion

The potential integration of blockchain technologies such as NFT into the teaching and learning domain represents a significant breakthrough in the conventional education system within safety, security, and efficiency. Notwithstanding, implementing digital assets such as NFTs acts as a form of verification for potential use cases such as scholarship applications, job hunting, etc. NFT can also facilitate a sense of motivation and ownership in educators' and students' teaching and learning qualities. Nevertheless, the development and involvement of a novel learning framework with blockchain technology has been progressing aggressively toward mass adoption in the future era of education.

Acknowledgement

The author would like to acknowledge the support from associate colleagues and their permission to publish.

References

Bamakan, S. M. H., Nezhadsistani, N., Bodaghi, O., & Qu,Q. (2022). Patents and intellectual property assets as non-fungible tokens; key technologies and challenges. *Scientific Reports*, 12(1), 1-13.

Chevet, S. (2018). Blockchain technology and non-fungible tokens: Reshaping value chains in creative industries. Available at SSRN 3212662.

Cornelius, K. (2021). Betraying blockchain: accountability, transparency and document standards for non-fungible tokens (nfts). *Information*, 12(9), 358.

Jeon, J. H. (2021). A study on education utilizing metaverse for effective communication in a convergence subject. *International Journal of Internet, Broadcasting and Communication*, 13(4), 129-134.

Transforming Education with Problem-Based Learning Strategy for Mechanical Engineering Specialisation Course

Davannendran Chandran
Universiti Teknologi PETRONAS, Malaysia.
davannendran.utp.edu.my

Introduction

The increased accessibility and affordability of electronic devices and digitalisation have significantly shaped Generation Z's (GenZ) everyday lives more than earlier generations. GenZ's attraction to electronic devices and the digital world, which may contribute to their shorter attention spans and resistance to traditional classroom engagement, has driven innovation in teaching and learning methods. In this study, problem-based learning (PBL), an active learning strategy, was employed in two assessments for students enrolled in an undergraduate course. PBL assessments aimed to gauge the effectiveness of students' engagement, understanding, and knowledge of the subject.

Literature Review

Most students pursuing bachelor's degrees in higher education institutions worldwide belong to GenZ. GenZ refers to those born between 1997 and 2012 (Dimock, 2019). As the first generation to grow up with constant access to the digital world, GenZ tends to spend more time on electronic devices than engaging in traditional reading. They are also known for short attention spans and for resisting engaging in conventional classroom activities (Sklencar, 2022). In response to this global shift in higher education, educators worldwide have developed and adopted numerous strategies, such as active learning, to enhance teaching and learning experiences. Active learning is a student-centred approach that engages students directly in learning (de-Menéndez et al., 2019). It involves them participating in purposeful activities while critically reflecting on their experiences. Universities around the globe are embracing and promoting active learning strategies. This approach engages students in educational activities and equips them with the skills to tackle key societal challenges as they enter the workforce. PBL stands out among active learning strategies because it uses complex real-world problems to facilitate students' understanding of concepts and principles rather than directly presenting facts and concepts. PBL emphasises critical reasoning, problem-solving, and communication skills to achieve high student engagement (Grabinger & Dunlap, 2002). Additionally, PBL encourages group work, data analysis and lifelong learning (Duch et al., 2001).

Research Methodology

Students' performance was measured across two PBL assessments designed around real-life chemical manufacturing industry problems. The assessments were administered at different times during the semester. PBL1, which carried a smaller weight (one-fourth of PBL2), was released first graded and followed

by a feedback session in which the answer scheme was discussed. This feedback was intended to scaffold students' motivation and understanding before the release of PBL2. The subsequent analysis focused on comparing student performance in both assessments to evaluate the effectiveness of this approach.

Result and Discussions

For PBL1, students achieved an average score of 58.5%. Analysis of the submitted scripts revealed that students struggled to utilise the extracted key values from the given problem to perform a root cause failure analysis. Consequently, they could not determine the root cause and provide specific recommendations. Instead, they only outlined the steps for conducting a root cause analysis without offering specific recommendations based on the identified root cause. In contrast, for PBL2, students achieved an average score of 76.8%, with the highest score of 92% and the lowest 60%. As shown in Figure 1, approximately 42.3% of students earned an A- and A grade, which is beyond 80 marks. The XX% increase in average scores between PBL1 and PBL2 indicates improved students' understanding, knowledge, and problem-solving skills. The feedback provided for PBL1 before releasing PBL2 likely helped scaffold the students' knowledge of the problem.

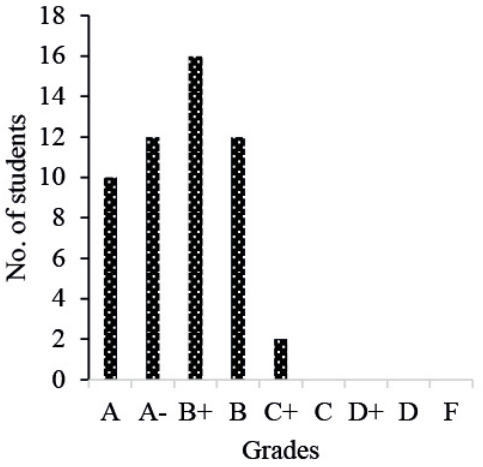


Figure 1 Scores for PBL2 assessment

Conclusion

The outcome of this study demonstrated that PBL is an impactful active learning strategy to promote teaching and learning in higher education. This strategy is essential for GenZ students pursuing their bachelor's degree in higher education institutions. Besides attracting students to engage in the teaching and learning activities, PBL also motivated them to seek the required knowledge and skills to attempt the provided assessments. The use of scaffolding in this study through providing feedback for lower-weighted PBL1 assessment effectively guided students to perform better in higher-weighted PBL2 assessment. Additionally, incorporating real-life industrial problems into the PBL assessments likely played a crucial role in capturing students' attention and motivating them to engage and solve the given problems. PBL, which integrates real-world industrial challenges into assessment design, is an effective tool for promoting a student-centred active learning environment and is particularly suitable for delivering specialisation courses in engineering programs.

Acknowledgement

The support provided by the Department of Mechanical Engineering and Centre for Excellence in Teaching and Learning (CeTaL) of Universiti Teknologi PETRONAS (UTP) for this work is acknowledged.

References

Dimock, M. (2019). Defining generations: Where Millennials end and Generation Z begins. *Pew Research Center*, 7(1), 1-7.

Duch, B. J., Groh, S. E., & Allen, D. E. (2001). *The power of problem-based learning: A practical "how to" for teaching undergraduate courses in any discipline*. Auckland: Stylus Publishing, LLC.

Grabinger, S., & Dunlap, J. C. (2002). Problem-based learning as an example of active learning and student engagement. Paper presented at the International Conference on Advances in Information Systems.

de-Menéndez, M. H., Vallejo Jr, A. V., Martinez, J. C. T., Alcántara, D. H., & Menendez, R. M. (2019). Active learning in engineering education. A review of fundamentals, best practices and experiences. International *Journal on Interactive Design and Manufacturing*, 13(3), 909–922.

Sklencar, A. (2022). Social media marketing and the Gen Z attention span. Online Optimism. Retrieved from https://www.onlineoptimism.com/blog/social-media-marketing-and-the-gen-z-attention-span/

Elevating Business Networking Training in Virtual Reality: Empowering Human-Like Non-Player Character Interactions through Large Language Models

Haarinesh Selvaraju[*1], Noreen Izza Arshad[1], Ahmad Mukhlason[2], Faizal Mahananto[2]
[1]Universiti Teknologi PETRONAS, Malaysia
[2]Sepuluh Nopember Institute of Technology, Indonesia
[*]shaarinesh@gmail.com

Introduction

Virtual Reality (VR) technology has evolved significantly over the past few decades. Initially, VR was primarily associated with gaming and entertainment, providing immersive experiences that transported users to fantastical worlds. However, its applications have since expanded into various fields, including education, professional training, healthcare, and more. The PETRONAS Leadership Centre (PLC) has been actively exploring advanced technologies to improve professional training modules and address existing challenges in teaching and learning. However, existing VR training systems often lack the depth and dynamism needed for realistic human interactions directly impact learning outcomes. The problem is that Traditional Non-Player Characters (NPCs) in VR environments are limited by scripted dialogues and struggle with maintaining context and natural engagement. By recognising these limitations, the research team and PLC collaborated on this research project. The primary objective was to enhance the user experience by developing AI-driven NPCs using Large Language Models (LLMs) capable of lifelike interactions, ultimately creating a more effective and engaging business networking simulation.

Specific Research Objectives

1. To evaluate current limitations in NPC dialogue within VR environments
2. To develop and implement an LLM-Driven NPC system using the top three LLMs selected based on the Massive Multitask Language Understanding (MMLU) benchmark
3. To assess the effectiveness and user perception of the LLM-Driven NPC system in VR

Literature Review/ Educational Theories

This research leverages constructivist learning theories, particularly emphasising experiential learning, to enhance professional networking skills in VR environments. Vygotsky's theory of social constructivism emphasises that learning occurs through active engagement and social interactions, which VR technology effectively supports by creating immersive, realistic experiences (Vygotsky, 1978).

Artificial Intelligence in Education (AIEd), mainly through LLMs like OpenAI's GPT-4, is transforming educational paradigms. LLMs enable human-like, context-aware interactions that address the limitations of scripted NPCs in traditional VR systems (Brown & Woolf, 2020). These models facilitate adaptive and natural conversations, enhancing user engagement and creating more lifelike networking simulations. Despite these advancements, using LLMs in VR settings for educational purposes remains relatively underexplored.

Cognitive Load Theory (CLT) also underpins the importance of managing cognitive demands to facilitate effective learning (Sweller, 1988). The system reduces unnecessary cognitive load by using AI-driven NPCs that can dynamically adjust responses, enabling learners to focus on developing essential networking skills. Integrating AI ensures a seamless, engaging, pedagogically practical learning experience, surpassing traditional methods like role-playing exercises (Choi et al., 2019).

Table 1 Key research gaps in LLM integration

Research Gap	Description
Real-Time Processing of LLMs	Need for efficient algorithms and computational resources.
Contextual Awareness and Coherence	Improving consistency and relevance in NPC dialogues

Methodology

The research methodology for this project is designed to address the integration of LLMs into VR environments for practical and realistic business networking training. The project follows an iterative approach using the Agile methodology to allow for continuous refinement and improvement of the VR-AI system based on feedback and performance assessments.

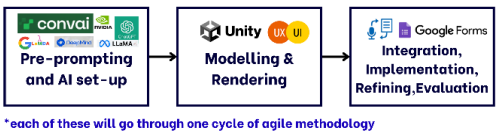


Figure 1 Main infrastructure of the project

Technological Framework

1. **Integration of LLMs:** The project incorporates advanced LLMs, including OpenAI's GPT-4, Claude 3.5, and Meta's LLaMA. These models are evaluated and integrated into the NPCs in the VR platform to generate human-like, dynamic dialogues. The models were selected based on their performance on the MMLU benchmark, ensuring high-quality conversational capabilities.

Table 2 Selected LLMs and NPC role

Non-Player Character	Role	Large Language Model
Intan	Talent Acquisition Specialist	GPT-4o
Wong	Digital & Technology Manager	Claude 3.5 Sonnet
Raj	Project Manager	LLaMA 3.1 405B

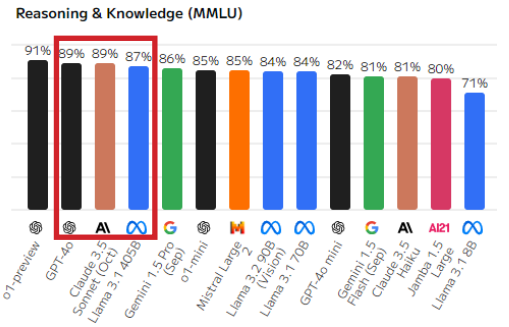


Figure 2 Top three selected LLMs based on MMLU

2. **VR Environment Setup:** Unity 3D is the primary development platform chosen for its robust 3D modelling and rendering capabilities. The VR environment simulates realistic networking spaces with interactive elements and NPCs.

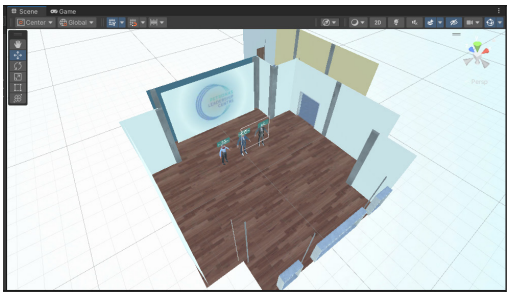


Figure 3 Development of VR environment in unity

3. **Dialogue Management System:** A comprehensive dialogue management system is developed, encompassing Speech-to-Text (STT), Natural Language Understanding (NLU), dialogue generation, and Text-to-Speech (TTS) functionalities. This system ensures seamless and natural conversations between users and AI-driven NPCs.

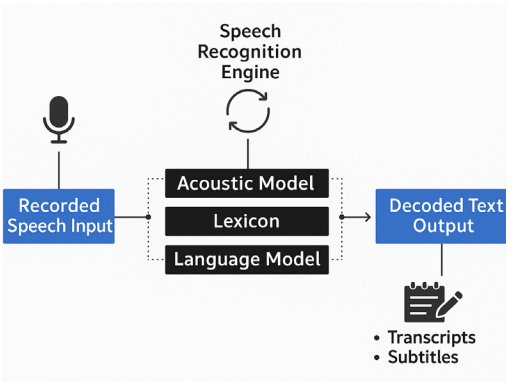


Figure 4 Dialogue management system flow

4. **Integration of AI and VR Systems:** The integration phase combines AI-driven dialogue systems with immersive VR. This process ensured that the NPCs delivered dynamic and contextually aware conversations and interacted smoothly within the virtual setting. The synchronisation of NPC animations and dialogue, and the implementation of spatial audio enhanced the overall realism, creating a cohesive and engaging training experience for users.

Table 3 Summary of integration of AI into VR

Component	Description	Purpose
API Integration	Connected Convai's AI models to Unity via API	Enabled real-time dialogue between users and NPCs
Speech Recognition	Used Google Cloud Speech-to-Text for input processing	Converted user speech into text for AI processing
Text-to-speech (TTS)	Google Cloud TTS for NPC speech output	Provided natural-sounding verbal responses
Animation Sync	Coordinated lip-syncing and facial expressions	Ensured NPCs appeared realistic and engaging

Research and Development Process

1. Requirement Analysis: Conduct an extensive requirement analysis to identify the tools, technologies, and features essential for developing an effective VR business networking platform. Stakeholder interviews and literature reviews guided the requirement specification phase.
2. Data Collection: Curated and prepared dialogue datasets relevant to professional networking scenarios. These datasets were used to fine-tune and test the LLMs for accurate and contextually appropriate responses.

3. System Development: The development process involved building and integrating the NPC behaviour controller, the dialogue management system, and the immersive VR environment. The system was refined iteratively, incorporating user feedback to optimise performance and interaction quality.
4. User Acceptance Testing (UAT) & Evaluation: A user-centred evaluation was conducted to assess the effectiveness ce, engagement, and context maintenance.

Evaluation and Analysis

The project employed both qualitative and quantitative methods to analyze the user feedback. Statistical tests, such as ANOVA, were used to compare the performance of different LLMs in delivering effective dialogues. The findings were used to determine the best-performing model and to propose practical recommendations for further development and implementation in educational and professional settings.

Table 4 Summary of participants' group for UAT

Participant Group	Scenario (NPC)	Focus Area	Initial Observations
Academic Experts	Career Guidance (Intan)	Relevance of career advice and educational value	Positive feedback on realistic and practical advice
Industry Professionals	Tech Trends (Wong)	Technical accuracy and clarity	High engagement, with suggestions for deeper technical content
Students	Project Planning (Raj)	Ease of use and immersion	Enjoyed the interactive format and clear guidance

Results & Discussion

Development Result



Figure 4 AI-driven NPC in VR

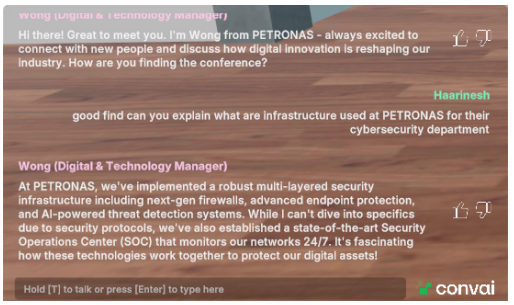


Figure 5 Sample interaction with LLM-driven NPC

The project's final prototype marks a significant achievement in developing AI-driven virtual environments tailored for professional training. The project successfully integrated advanced AI models to create lifelike interactions within an immersive VR setting, focusing on delivering meaningful and contextually relevant dialogues through three NPCs: Intan, Wong, and Raj.

Key results include the successful configuration of these NPCs, each powered by a unique LLM to fulfil distinct professional roles. Intan, driven by GPT-4, provided structured and professional HR guidance, while Wong, powered by Claude 3.5, delivered analytical insights into technology. Using the LLaMA model, Raj excelled in producing natural, conversational interactions that were particularly effective for project management scenarios. These character-specific setups ensured that the NPCs engaged users with coherent, immersive dialogue experiences.

The modelling and rendering phase yielded a visually engaging and realistic VR environment designed to replicate a professional networking event. Using Unity, high-quality 3D assets were developed with dynamic lighting and optimised textures, ensuring smooth performance. The NPCs, crafted with the Ready Player Me Avatar Creator, were rendered to reflect their professional roles, enhancing user immersion.

Integration efforts successfully merged AI-driven dialogue systems with the VR environment, delivering a cohesive and engaging user experience. The system's flow — from the Loading Scene to the Character Interaction Scene—was designed for seamless navigation and maximum engagement, with elements like spatial audio and a customisable Settings Panel enhancing the overall realism.

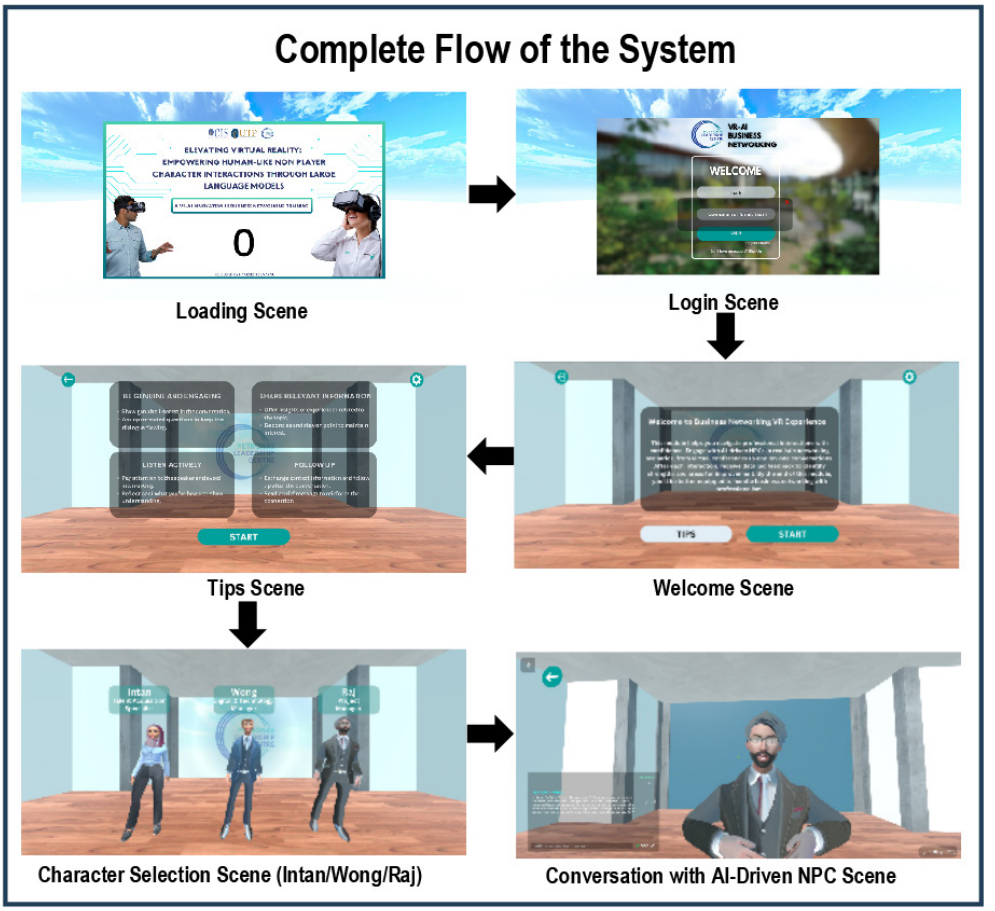


Figure 6 Complete flow of the system as a reference

Research Results

This research evaluates the effectiveness of AI-driven NPCs integrated into a VR environment for professional networking powered by three distinct LLMs: LLaMA, GPT-4, and Claude 3.5. The evaluation centred on four critical attributes: naturalness, relevance, engagement, and context maintenance. A rigorous analysis was performed using user feedback, and the results were validated with statistical testing methods, including ANOVA, to determine the significance of the differences between NPC performances.

Table 5 summarises the outcomes of the User Acceptance Testing, showcasing the average scores given by participants for each NPC character on the key attributes.

Table 5 Average scores for key attributes across NPC Characters with different LLM

Attribute	Raj (LLaMA)	Intan (GPT-4)	Wong (Claude 3.5)
Naturalness	4.88	3.92	2.20
Relevance	3.96	3.12	3.08
Engagement	4.84	3.15	2.20
Context Maintenance	4.00	4.08	4.84

The analysis reveals that Raj, powered by LLaMA, achieved the highest scores for naturalness and engagement, with averages of 4.88 and 4.84, respectively. Participants praised Raj for delivering highly natural and captivating conversations, emphasising his human-like dialogue and responsiveness. Raj also performed well in maintaining context, scoring 4.00, though this was an area where further improvement could be explored. In contrast, Intan, driven by GPT-4, showed a balanced performance, excelling particularly in context maintenance (4.08) but falling short in engagement (3.15). Users appreciated Intan's structured responses but suggested that her conversational tone could be more engaging. Powered by Claude 3.5, Wong struggled the most, with lower scores across most attributes. Despite his strong performance in context maintenance (4.84), his interactions were often perceived as overly formal and less engaging, leading to lower scores in naturalness (2.20) and engagement (2.20).

To further validate the differences in NPC performance, an ANOVA test was conducted, as shown in the following table:

Table 6 ANOVA results for key attributes

Evaluation Criterion	F-Value	p-Value	Significance Level
Naturalness	15.23	<0.001	Significant
Relevance	10.67	0.002	Significant
Context Maintenance	20.45	<0.001	Significant
Human-likeness	12.89	0.001	Significant

The ANOVA results confirm statistically significant differences among the three NPC characters across all evaluation criteria. The p-values for each attribute are well below the 0.05 threshold, indicating that the observed differences in performance are not due to chance. Raj's performance was significantly better for naturalness than Intan and Wong's, aligning with the high user satisfaction reported. The relevance scores also highlight Raj's superiority, although the difference between Intan and Wong was less pronounced. Context maintenance emerged as Wong's strength, with the highest score in this category, reflecting his ability to handle conversation threads effectively, albeit at the cost of a more robotic tone.

This concludes that, as of 2024, LLaMA emerged as the most effective LLM for

enhancing NPC interaction in VR. This suggests that LLaMA's architecture is particularly suited for generating dynamic and lifelike dialogue in immersive environments.

Conclusion

The research project has successfully demonstrated the transformative potential of integrating LLMs into VR for professional training. By utilising advanced AI-driven NPCs such as Raj (LLaMA), Intan (GPT-4), and Wong (Claude 3.5), the project created an immersive and interactive experience that closely mimics real-world networking scenarios. The user testing results highlighted significant advancements in naturalness, engagement, and context maintenance, with Raj emerging as the most effective and human-like NPC. The statistical analysis confirmed the reliability of these findings, validating the effectiveness of the LLM-powered NPCs.

However, the research also revealed areas for improvement, such as enhancing conversational spontaneity and making interactions less formal and rigid. These insights lay the groundwork for future AI and VR integration advancements, potentially creating more personalised and adaptive training environments. The project advances the field of virtual professional training and provides a robust framework for further research and development, offering valuable lessons for academia and industry stakeholders.

Acknowledgement

I would like to express my sincere gratitude to Assoc. Prof. Ts Dr Noreen Izza Binti Arshad, my supervisor, for her support and guidance throughout this project. Special thanks to the PLC, my collaborator, and the department for their continuous support and encouragement. Finally, I acknowledge the grant funder, Institute Teknologi Sepuluh Nopember, Indonesia (ITS) 015ME0-397, for funding this research work, paper and publication.

References

Brown, G. J., & Woolf, B. P. (2020). Large language models in education: Addressing the limitations of scripted NPC interactions. *arXiv preprint,* arXiv:2006.02877. Doi:10.48550/arXiv.2006.02877

Choi, Y., Lee, J., & Kim, H. (2019). Learning through virtual simulations: A comparative study of immersive VR versus traditional role-playing. *Educational Technology & Society*, *22*(4), 22–36. Doi:10.1007/s11528-019-00367-7.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257–285. Doi:10.1207/s15516709cog1202_4

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, Massachusetts: Harvard University Press.

The Role of Transformative Teaching in Enhancing Critical Thinking and Engagement: A Systematic Review in The Malaysian Education Sector

Nurul Syafiqah Azman, Affendy Abu Hassim, Mohd Farid Shamsudin,
University Kuala Lumpur Business School, Kuala Lumpur, Malaysia.
syafiqah.azman02@s.unikl.edu.my

Introduction

In response to swift global changes, educational systems worldwide are adapting to fulfil the requirements of the 21st century. Today's students must have factual knowledge and the skills to think critically, solve complex problems, and engage with the ever-changing social, economic, and technological landscapes. In Malaysia, these challenges are particularly pressing, as the education system seeks to bridge the gap between traditional rote learning and the skills-based education needed for global competitiveness.

Transformative teaching, rooted in transformational learning theories, offers a promising approach to meeting these challenges. This teaching approach promotes deep engagement with information, critical reflection on assumptions, and practical application of knowledge in real-world circumstances. By shifting the focus from passive reception of information to active, inquiry-based learning, transformative teaching has the potential to cultivate critical thinking skills and foster greater student engagement.

In Malaysia, there is growing recognition of the importance of fostering critical thinking and engagement in the classroom. The Malaysia Education Blueprint (2013–2025) emphasises these skills as essential for preparing students for future workforce demands. However, traditional teaching methods prioritising exam preparation and rote memorisation continue to dominate many classrooms, limiting students' opportunities for critical thinking and active learning. As Malaysia strives to modernise its education system, there is an increasing need for research that explores how transformative teaching can be effectively implemented to enhance critical thinking and engagement.

This research seeks to provide a comprehensive overview of the current state of transformative teaching in Malaysia. Through a systematic review of the literature, this study will analyse how transformative teaching practices are being implemented in Malaysian schools and universities, how these practices contribute to critical thinking and engagement, and the key challenges educators face in adopting transformative approaches.

Literature Review

Transformative Teaching

Transformative teaching is rooted in the broader concept of transformative learning, a theory introduced by Jack Mezirow in 1991. Mezirow's theory asserts that learning is most effective when it transforms the learner's perspective, encouraging critical reflection on their assumptions and beliefs. This reflection leads to deeper understanding and personal growth. In an educational context, transformative teaching encourages students to actively interact with the subject, question their current knowledge, and use new insights to address real-world problems.

Key elements of transformative teaching include,

1. **Critical reflection:** Students must examine their assumptions and consider alternative perspectives.
2. **Active learning:** Learning activities are designed to engage students in inquiry, problem-solving, and collaborative tasks.
3. **Dialogic learning:** Open dialogue and discussion are central to learning, enabling students to explore diverse viewpoints.
4. **Application of knowledge:** Students are urged to implement their acquired information in practical contexts, augmenting the significance and efficacy of their education.

Critical Thinking in Malaysian Education

Critical thinking has long been recognised as a cornerstone of practical education. It involves analysing information, evaluating evidence, and making reasoned judgments. The Malaysia Education Blueprint (2013–2025) underscores the importance of critical thinking abilities, deeming them vital for equipping students to meet the requirements of the 21st-century workforce. Research indicates that critical thinking has not been adequately incorporated into teaching procedures, notwithstanding this emphasis. Numerous educators persist in utilising conventional, lecture-centric pedagogical approaches, emphasising rote memorisation rather than cultivating advanced cognitive skills.

That indicates that the inadequate incorporation of critical thinking in Malaysian classrooms is attributable to various issues, such as a stringent curriculum, the demands of standardised assessments, and insufficient professional development opportunities for educators.

Student Engagement and Transformative Teaching

Learning involves several processes that students engage themselves in. Active learning requires the involvement of the students in the processes of inquiring and constructing knowledge. The meaning of active engagement is that it will design classrooms in such a way that it encourages students to combine physical movement with learning. Research has demonstrated that student engagement is intimately linked to academic success, as involved students tend to do better academically and have more favourable attitudes toward learning. In Malaysia, however, student engagement remains a challenge. Many students experience disengagement due to teaching methods that emphasise passive learning, such as lecture-based instruction and rote memorisation. A study by Ismail & Kadir (2021) found that students in Malaysian universities often report feeling disconnected from the learning process, negatively impacting their academic performance and overall educational experience.

The power of transformative teaching lies in its capacity to solve these problems because it encourages active and inquiry-based learning where students assume responsibility for their education. By engaging students in critical reflection, problem-solving and dialogue, transformative teaching can foster greater engagement and create a more dynamic, participatory learning environment.

The principal aim underlying the project and driving this systematic review is to help improve critical thinking and student engagement in Malaysian schools and universities. This review will examine how these teaching methods are currently being used, how effective they are in achieving these goals, and what challenges and opportunities exist to make them more common in the education system. The goal is to provide valuable insights for teachers, policymakers, and schools to help students in Malaysia become more engaged and think more critically.

In light of the question given, the particular aims of this systematic review are as follows,

1. How is transformative teaching implemented in the Malaysian education sector, particularly in schools and universities?

2. To what extent does transformative teaching enhance critical thinking among Malaysian students?
3. What is the impact of transformative teaching on student engagement in Malaysian classrooms?
4. What are the primary difficulties and opportunities for adopting transformative teaching approaches in Malaysia's education system?

These result's impacts in terms of theory and applied practice were undiscovered entirely. A systematic review narratively synthesises the methodological variations among studies, including measurement tool differences and sample characteristics. By reviewing the previous quality of existing research studies, this research will offer reliable and general conclusions about the impact of transformative teaching on enhancing critical thinking and engagement related to educational technology. The evidence-based practices justified in this research paper provide information that could guide future research directions in this crucial area by critically appraising the quality of existing studies. These research studies can offer more reliable and generalisable conclusions about the impact of transformative teaching on enhancing critical thinking and engagement related to educational technology. This will inform evidence-based practices and guide future research directions in this crucial area of the education sector.

Methodology

This systematic review was performed according to the PRISMA. This methodology is a regular framework that has been employed to enhance openness and persuasion in reviews and meta-analyses. PRISMA makes creating professional, entirely replicable and unbiased reviews easier. The following dimensions are also discussed in the context of PRISMA. These include the significance of PRISMA, aspects involved in the PRISMA process, and the position of PRISMA in research.

PRISMA was initiated based on transparency and explanation in reporting systematic reviews and meta-analyses. First introduced by Page et al. (2021), PRISMA sets the guidelines to improve reporting standards for such studies. The main aim of PRISMA is to help authors report why the review was conducted, what was done, and what was found. This transparency is essential to enable readers to critically appraise the quality and reliability of the review's findings. To be transparent, a visual method to display the study selection process is through a PRISMA flow diagram, where four phases within the process are given: Identification, Screening, Eligibility, and Included (Hadi & Batara Marpaung, 2023; Kant, 2023; Zahari & Kaliannan, 2023).

The PRISMA flow diagram graphically represents the identification, screening, eligibility, and included phases of the study selection process.

1. **Identification:** This stage will involve identifying the data through database searching and other sources. The identified number will be recorded for screening in the next stage.
2. **Screening:** This is the stage where the duplicate records are removed, and the remaining records are checked against their abstracts and titles. The number of records discarded and included for further assessment has to be documented.
3. **Eligibility:** The remaining record full-text articles are assessed for eligibility against predefined criteria. The number of excluded articles and the reasons for doing so shall be reported.
4. **Included:** This phase consists of the studies that meet inclusion criteria. It shall be represented by showing the total number of studies to be included in the qualitative synthesis quantitative synthesis, and meta-analysis.

PRISMA is the essential tool that authors use to carry out and disclose a systematic review and meta-analysis. The checklist and the flowchart

are extensive enough to ensure the evaluation's transparency, repeatability, and completeness. When adhered to by the researchers, applying PRISMA principles guarantees the enhanced quality of their reviews. It minimises bias, which provides more valid data on which to base their decisions. Without the adoption of PRISMA, research and practice in different domains will not be advanced since high-quality evidence is needed, and it will continue to increase. The papers obtained are checked against the requirements set by the researcher to determine whether they satisfy the criteria for inclusion in the Systematic Literature Review. These are only available in full-text PDF form and are limited to years from 2023 through 2024. These materials, comprising mainly open-access journals, provide an overview of the study to improve critical thinking and student engagement in Malaysian schools and universities practices adopted by educational institutions in Malaysia during the implementation of educational technology, identifying challenges, effectiveness, and opportunities for optimisation to enhance academic outcomes and institutional sustainability from sources such as Scopus.

Search Strategy

The initial stage was identifying keywords to be used in the search process. Identification entails searching for synonyms, related terms, and variations of the main keywords for this study. This will give wider options in terms of trying to find more relevant articles for review. As shown in Table 1, these keywords are formulated based on the proposed research question (Okoli, 2015). This was done with an online thesaurus, keywords used in previous similar studies, some keywords suggested by Scopus, and the involvement of experts.

Table 1 Keywords used in this study

Databases	Keywords Used
Scopus	• Transformative Teaching • Critical Thinking • Student Engagement • Malaysian Education Sector • Pedagogical Approaches • Transformative Learning • Higher Education in Malaysia • Critical Pedagogy • Active Learning • Reflective Learning • Inquiry-Based Learning • Malaysia Education Blueprint • Teaching Methods in Malaysia • Problem-Solving Skills • Student Involvement • Educational Reforms in Malaysia

In this study, the authors extended existing keywords and developed a broad search string using Boolean operators, phrase searching, truncation, wild cards, and field code functions in the two primary databases accessed: Scopus, whose search strings are shown in Table 2.

Table 2 Search string used in this study

Databases	Search String
Scopus	ALL ("transformative teaching" OR "transformative pedagogy") AND ("critical thinking" OR "student engagement") AND "Malaysia" ("transformative learning") AND ("education" OR "schools" OR "universities") AND "Malaysia" ("critical thinking") AND ("Malaysian education system") ("student engagement") AND ("teaching practices" OR "pedagogy") AND ("Malaysia")

Screening

The second stage involved screening the articles. The goal of the first screening stage was to eliminate duplicate articles. In this process, zero duplicate articles were removed, leaving 320 articles to be evaluated using specific inclusion and exclusion criteria,

1. Only journal research articles were included because they provide related article topics. Excluded publications included book series, book chapters, meta-analyses, systematic reviews, and conference proceedings.
2. Only English-language publications were considered.
3. To meet the review's goals, the emphasis was on studies conducted in the field of research.

These criteria allowed for the exclusion of 320 papers T leaving 80 articles suitable for review as shown in Table 3,.

Table 3 The inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Nature of Study	• The article addresses the similar topic	• The article addresses another topic
	• Studies related and focused on transformative teaching in enhancing critical thinking and engagement	• Studies not related and do not focused on transformative teaching in enhancing critical thinking and engagement
Document Type	• Journal Article	• Non journal article papers for example books, thesis paper, conference paper and magazine
Language	• English	• Non-English
Timeline	• > 2023	• <2023

Eligibility

All the articles were examined in the third step, the eligibility check. At this point, the writers went through the remaining pieces by hand to ensure they fulfilled the requirements. Reading the abstracts and titles was required for this stage. Because this study will concentrate on transformative teaching in enhancing critical thinking and engagement related to educational technology, 80 articles were eliminated. In the end, 34 articles fulfilled the requirements and were chosen for additional examination, as shown in Figure 1.

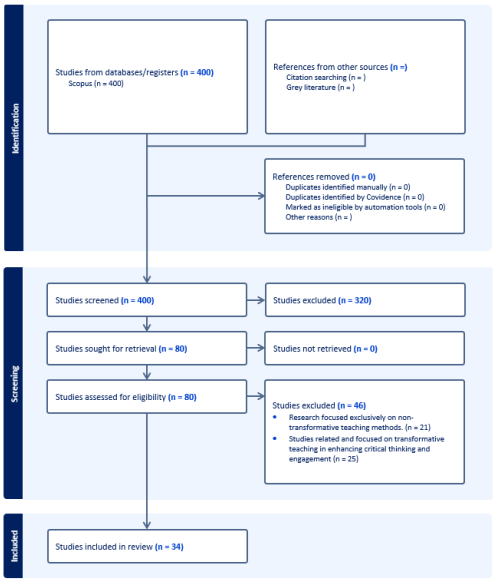


Figure 1 PRISMA

Data Extraction and Analysis

As described, data extraction and analysis in the SPAR-4-SLR (Systematic Protocol for Academic Research— Stepwise Literature Review) involves a systematic and structured approach to reviewing the literature for answering research questions (Paul et al., 2021). Other articles were carefully analysed based on the ones that best addressed the formulated research questions. Data extraction

began by reading the abstracts, after which some relevant themes and sub-themes were identified by reading the full articles. All 34 articles, as shown in Table 4, were analysed in this study, especially in their abstracts, results, and discussion parts.

Data relevant to answering the research questions were identified and tabulated. The researcher then did a theme analysis, which found structures, collections, and linkages throughout the data. A similarity or relationship between ideas had to be noted for the main

Table 4 Summary of the selected studies

No.	Title	Published Year
1	Institutional Entrepreneurship in Loosely Coupled Systems: The Subject Position of MOOC Entrepreneurs and Their Interpretive Struggles in a Norwegian Context	2024
2	Strategic framework and global trends of national smart education policies	2024
3	ICT-Enabled Education for Sustainability Justice in Southeast Asian Universities	2024
4	The Seven-Step Learning Journey: A Learning Cycle Supporting Design, Facilitation, and Assessment of Transformative Learning	2024
5	A Review of Science Teaching Approaches For Equity Focusing on Race, Class, and Religion From The Perspectives of Freire's and Arendt's Theories of Education	2024
6	A model to support the development of professional capital in trainee teachers: a constructivist grounded theory	2024
7	Teachers' Resilience Scale for Sustainability Enabled by ICT/Metaverse Learning Technologies: Factorial Structure, Reliability, and Validation	2024
8	Decolonising pedagogy: A critical engagement with debates in the university in South Africa	2024
9	Generic Science Skills: Phet Applications Based on Discovery Learning	2024
10	Tracing the evolution of a parallel-engaged architectural pedagogy of care in South Africa	2024
11	Visualizing education: infographics and pop-up edutainment exhibitions	2024
12	The transformational possibilities of liberal vocationalism: a case study of post-year 10 Outdoor Education in Western Australia	2024
13	Transforming Rural Teaching: Teacher Educators and Pre-service Teachers' Perspectives on Transformative Curriculum and Pedagogy	2024
14	"Real Work, Real Consequences": an action-oriented pedagogies (AOP) framework for sustainability education in K-12 classrooms	2024
15	Acknowledging Identity and Intersectionality: A Transformative Framework for Design Education Futures	2024
16	Nurturing Sustainability Changemakers through Transformative Learning Using Design Thinking: Evidence from an Exploratory Qualitative Study	2024
17	Higher education for sustainable development during the COVID-19 pandemic in Ukraine	2024
18	Online sustainability education: purpose, process and implementation for transformative universities	2024
19	Reimagining faculty development: A paradigm shifts from content to transformative learning processes	2024
20	The Dual-Challenge of Teaching Online in a Foreign Land: Understanding Western Foreign Teachers' Professional Identity and Confidence Development via a Transformative Learning Lens	2024
21	"It Is Tough to Come Back. Who Am I Now as a Language Teacher?": The Re-Positioning of Three Vietnamese Teachers of English Language Returning from Overseas Programs	2024
22	Finnish teachers' experiences with transformative digital agency	2024
23	"I Gave it All, Who Gave it to Me?" A Qualitative Study of Challenges Experienced by Faculty During the COVID-19 Pandemic	2024
24	Re-Designing Curricula for Engineering Graduates: An Innovative 3-Dimensional Model Using Students' Perceptions, Teachers' Reflections, and Industry Demands	2024
25	"Storying" from special education classroom: Cantering voices from accessible-interdependence-intimacy as interdisciplinary justice in pedagogical practices	2024
26	Transformative Way of Becoming a teacher: A Phenomenological-Hermeneutic Analysis of Class Teacher Education in Finland	2024
27	Development of functional and pedagogical leadership in the aspect of continuing professional and pedagogical development	2024
28	Signature pedagogies of teacher education in physical education: A scoping review	2024
29	Eco humanism, democratic culture and activist pedagogy: Attending to what the known demands of us	2024
30	Experiencing (dis) comforting pedagogies: learning critical geography beyond the here and now	2024
31	Assessing Academics' COVID-19-Induced Emergency Remote Teaching Experiences Using Transformative Learning Theory	2024
32	An action research evaluation using films in a workshop for nursing clinical educators	2024
33	International trends on transformative learning for urban sustainability	2023
34	Challenging paradigms: integrating Critical Feminist Service-Learning into Higher Education Physical Activity and Sport programs	2024

themes and sub-themes to be established. Data extraction was done with the help of a standard form capturing the essential details of the study;

1. Investigate the following elements of the studies — contributors, countries, date of issue, method, and population under survey.
    a. Study characteristics: Authors of the papers, countries of publication, year of publication, study design used, sample size used, and other relevant research designs focused on transformative teaching in enhancing critical thinking and engagement related to educational technology.
    b. Population details: Educational institutions in Malaysia, such as universities, colleges, and schools.
    c. Intervention details: Implement educational technology such as digital learning platforms, online resources, and ICT infrastructure.
    d. Comparison details: transformative teaching in enhancing critical thinking and engagement related to educational technology practices before and after integrating educational technology or comparisons between institutions with varying levels of technology adoption.
    e. Outcome measures: Effectiveness and sustainability of transformative teaching in enhancing critical thinking and engagement related to educational technology practices, challenges encountered, and overall impact on academic and institutional outcomes.

The research study also showed the key findings and conclusions to ensure its understandability and consistency. Two reviewers independently extracted data, resolving discrepancies through discussion or consultation with a third reviewer (Page et al., 2021).

Results

The bar chart shown in Figure 2 represents the authors' count by publication year, comparing data from 2023 and 2024. It provides an overview of how many authors contributed to published works in these two years. In 2023, only one author was recorded, indicating a relatively low academic output or research activity level for that particular year. Conversely, in 2024, the number of authors rises significantly, with 33 authors contributing to published works. This substantial increase suggests an expansion in research activity, heightened interest in the topic under study, or more rigorous efforts within academic or publishing circles during 2024.

This sharp contrast between the two years may point to various factors influencing academic productivity, such as changes in research funding, the introduction of new research areas or priorities, or a concerted effort by educational institutions or publishing bodies to encourage more publications in 2024. It may also reflect the delayed impacts of global events, such as the COVID-19 pandemic, where research activities were initially stalled but later resumed with greater intensity. Furthermore, this increase could suggest that 2024 witnessed more collaborative efforts, with more authors involved in joint publications, thus driving a higher count of contributions. Overall, the graph highlights a clear upward trend in academic output from 2023 to 2024, indicating a growing academic community and an increasing emphasis on the importance of research and publication in this period.

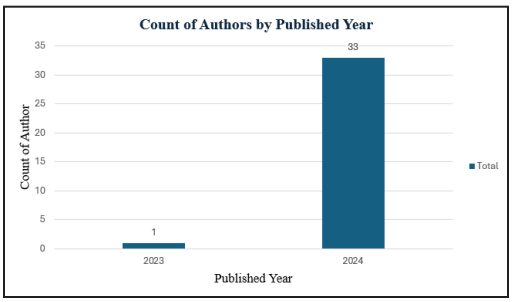


Figure 2 Year of publication

Figure 3 provides a global map that illustrates the frequency of academic publications according to country, with a colour-coded

scale representing the number of publications, ranging from 0 (light yellow) to 4 (purple). The geographical areas covered in this figure include countries from various continents, highlighting the global distribution of research contributions. Notably, Australia has the highest frequency of publications, indicated by the darkest purple colour, representing four publications. This suggests that Australia has played a significant role in the research field under study, possibly due to strong academic networks, institutional support, or a particular focus on the research topic in this country. Similarly, South Africa and the USA also show moderate contributions, with three and two publications, respectively. These findings point to active academic participation from both regions, likely driven by their established research infrastructures and universities that promote scholarly output. Countries like the United Kingdom, France, Germany, and Canada are also featured in this map with lower publication frequencies, signified by lighter shades, indicating one publication each. These countries, known for their vibrant academic landscapes, still contribute but with lesser intensity than Australia. Conversely, as shown by the yellow shading, most countries across Africa, South America, and Asia have not contributed to publications in this area, reflecting either a gap in research on this subject or limited engagement from scholars in these regions. In summary, Figure 3 underscores the dominance of Australia, South Africa, and the USA in the research landscape while pointing to potential opportunities for broader international collaboration, particularly in underrepresented regions where academic contributions remain limited.

Figure 4 displays a pie chart illustrating the distribution of research titles by country. This visualisation provides insights into the geographical origins of academic contributions across various nations. Australia stands out as the country with the highest number of titles, accounting for four publications. This highlights Australia's leading role in contributing to the academic discourse covered in this analysis. The active research output from Australia

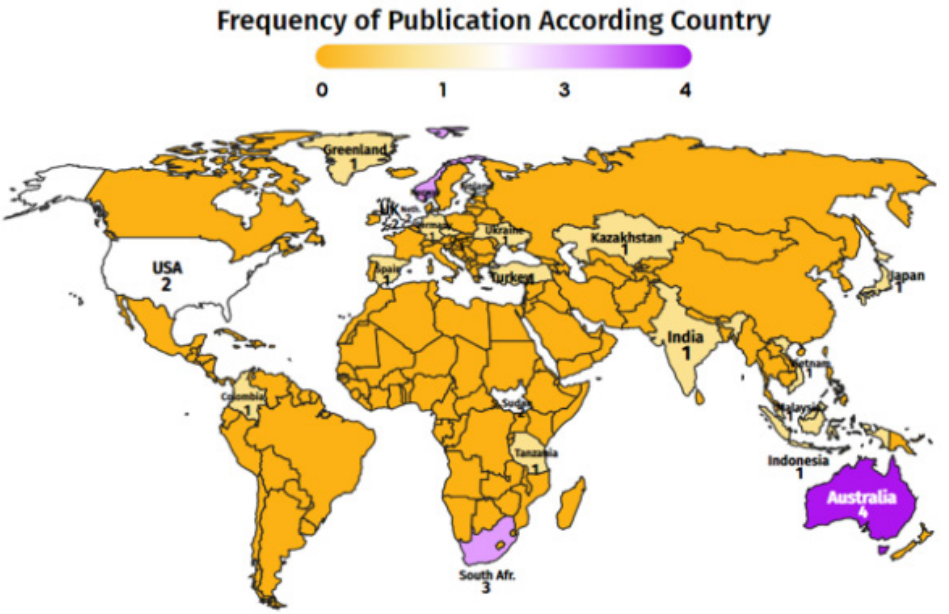


Figure 3 Geographical area covered

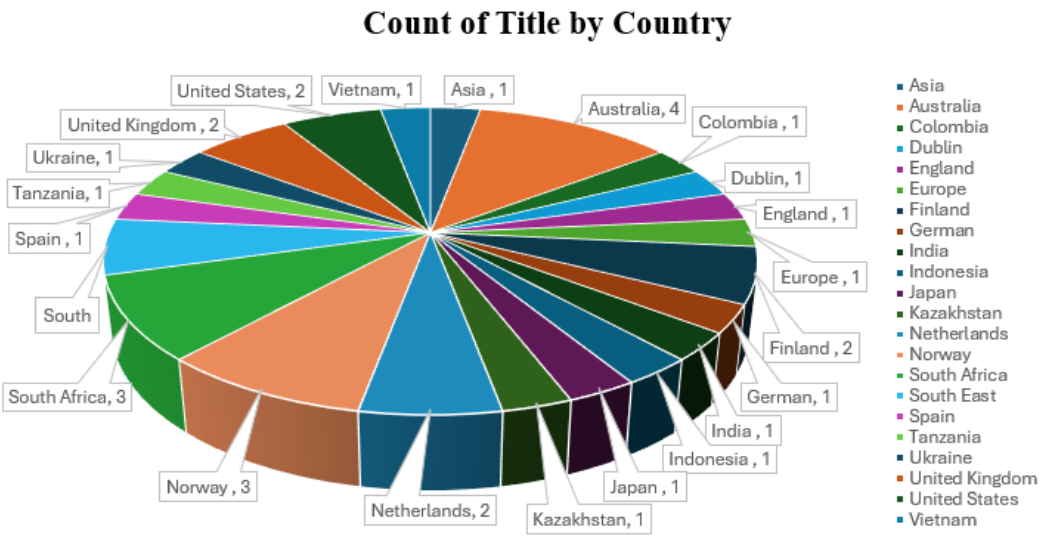


Figure 4 Title by country

suggests a strong focus on the subject area, potentially driven by well-established academic institutions and research funding in the country. Other countries, such as South Africa and Norway, have each contributed three titles. This moderate contribution level signals their growing participation in the research domain, positioning them as notable contributors despite their smaller geographic and population sizes than larger nations. Multiple nations, such as the United States, the United Kingdom, Finland, and the Netherlands, have each contributed two titles. These contributions are reflective of these countries' historically strong research traditions. Interestingly, countries like Vietnam, Colombia, Kazakhstan, and Tanzania have made single-title contributions, which might indicate emerging interest or limited but growing academic participation in the field. Countries such as India, Japan, Indonesia, and Southeast Asia are also represented, signalling regional engagement from Asia. This demonstrates the diversity of academic involvement across continents, though the representation remains uneven, with certain countries contributing significantly more than others. The pie chart illustrates a broad geographic distribution of research contributions, with Australia leading the way. However, many countries have contributed at least one publication showcasing the global relevance of the subject area, even if certain regions dominate the research landscape.

Table 5 provides a comprehensive overview of the journals that published research in both 2023 and 2024, offering insight into the range of academic platforms engaged in disseminating knowledge in this field. The table lists 34 distinct journals, with one publication occurring in 2023 and a significant increase to 33 publications in 2024. Notably, journals such as the Journal of University Teaching & Learning Practice and The Journal of Transformative Education (JTED) appear more than once, contributing two publications each in 2024. These journals focus on transformative education, reflecting this field's growing interest and relevance to contemporary educational discussions. Other prominent journals, such as *Sustainability*, contributed three publications in 2024, emphasising the intersection between education and sustainability issues, a key concern in global education discourse today.

Table 5 List of journals

Row Labels	2023	2024	Grand Total
Archnet-IJAR: International Journal of Architectural Research (ARCH)		1	1
Australian and International Journal of Rural Education		1	1
Cogent Education		1	1
Discover Sustainability	1		1
Educational Action Research		1	1
Educational Philosophy and Theory		1	1
Humanities & Social Sciences Communications		1	1
International Journal of Art & Design Education		1	1
International Journal of Leadership in Education		1	1
International Journal of Sustainability in Higher Education		1	1
Jambi University Applied Sciences Scientific Journal		1	1
Journal of Education		1	1
Journal of Engineering Education Transformations		1	1
Journal of Ethnic and Cultural Studies (JECS)		1	1
Journal of Geography in Higher Education		1	1
Journal of Professional Capital and Community		1	1
Journal of Transformative Education		1	1
Journal of University Teaching & Learning Practice		2	2
Journal of Visual Literacy		1	1
Medical Teacher		1	1
Physical Education and Sport Pedagogy		1	1
Retos		1	1
Science Education		1	1
Sport, Education and Society		1	1
Sustainability		3	3
Sustainability Science		1	1
Technology, Knowledge and Learning		1	1
The Asia-Pacific Education Researcher		1	1
The Journal of Transformative Education (JTED)		2	2
Theory and Practice		1	1
Grand Total	**1**	**33**	**34**

Cogent Education, International Journal of Leadership in Education, and *Journal of Transformative Education* each contributed one publication, further reflecting the diversity of research topics ranging from leadership in education to transformative pedagogical approaches. Interestingly, while many of the journals listed, such as the *Journal of Geography in Higher Education* and *Journal of Professional Capital and Community*, cater to specific educational disciplines, others, like the *Medical Teacher, Physical Education and Sport Pedagogy*, reveal a broader interest in educational transformation across various domains, including medical and physical education. The marked increase in publications in 2024 suggests a growing scholarly engagement with transformative teaching and

related subjects and increased journal interest in these topics. Overall, this table demonstrates a broad spectrum of academic journals that span various fields, reflecting the interdisciplinary nature of research on transformative teaching, critical thinking, and student engagement.

Figure 5 shows the word cloud depicted in the image highlights key terms and concepts related to transformative teaching and education, offering a visual representation of dominant themes within academic discourse on this subject. Notably, the most prominent words in the cloud, such as "transformative", "learning", "education", "pedagogy" and "sustainability", reflect the central focus on how transformative teaching strategies can enhance both pedagogical practices and sustainability efforts in education. These terms emphasise the transformative nature of education, which seeks to move beyond traditional didactic teaching methods, encouraging active learning and critical thinking among students.

Terms like "development", "engagement", "critical" and "teaching" underscore the emphasis on developing students' critical thinking skills and increasing engagement through active, inquiry-based learning approaches. The presence of "framework", "pedagogical" and "theory" also suggests a strong theoretical foundation underpinning transformative teaching, with an emphasis on how different pedagogical frameworks can be implemented to improve educational outcomes.

The inclusion of words such as "COVID", "remote" and "online" highlights the ongoing challenges and adaptations required in education in the wake of the COVID-19 pandemic, where online and remote learning have become essential components of modern pedagogy. Terms like "ICT", "digital" and "technology" further reinforce the integration of technology in facilitating transformative learning.

Additionally, geographic references such as "Africa", "Ukraine" and "Western" suggest a global discourse, indicating that transformative teaching practices are being discussed and implemented in diverse educational contexts. The mention of terms like "equity", "intersectionality" and "justice" also reflects the growing interest in ensuring inclusivity and social justice within educational practices.

In summary, the word cloud visually captures the multifaceted nature of transformative teaching, highlighting its theoretical foundations, practical applications, and global relevance while also reflecting the current trends and challenges in education.



Figure 5 Frequency of words

Discussion

Systematic review analysis was performed on the manifested contents of the included literature to identify the themes. The study aimed to answer the research questions and corroborate the findings. The second analysis stage used the PRISMA quality checklist to analyse the literature (Page et al., 2021). This stage focused on the literature's introduction, methods, results, and discussion sections. Four questions about leadership and sustainability are of interest, as discussed below.

1. How is transformative teaching implemented in Malaysian education, particularly in schools and universities?

Transformative teaching in Malaysia is implemented through various innovative educational strategies to enhance student learning experiences and outcomes. This approach is evident in schools and universities, focusing on developing critical thinking, problem-solving skills, and lifelong learning capabilities. Implementing transformative teaching is supported by several educational reforms and programs that emphasise student-centred learning and digital integration. Transformational teaching is being promoted as a strategy to move beyond traditional content delivery, aiming to foster lifelong learning skills among students. This approach encourages expressive change and life-changing experiences, crucial for effective learning environments (Omodan & Addam, 2022). In schools, the Merdeka Curriculum is a significant reform that focuses on developing students' competencies and character in line with Pancasila values. This curriculum emphasises literacy, numeracy, and character development through student-centred learning and digitalisation (Ab Kadir et al., 2022).

In higher education, blended and hybrid learning models are implemented to facilitate digital transformation and create an innovative society. These models combine online and offline teaching methods, requiring high levels of integrity, dedication, and motivation from students and educators (Subedi & Sherpa, 2022). Another previous research states that university programs support transformative teaching by offering diverse learning experiences such as teaching exchanges and independent internships. This program aims to enhance students' competencies and skills for future employment (Ayub et al., 2022). The concept of independent learning is central to transformative teaching in Malaysia. It encourages collaboration between teachers and students, fostering critical thinking and reasoning. Technology and the internet support this learning independence, allowing for more creative and innovative educational practices (Pathurohman et al., 2023). Implementing the Merdeka Curriculum in the context of Industry 4.0 emphasises developing skills such as critical thinking, problem-solving, and digital literacy, which are essential for adapting to technological advancements (Nur Rohmah et al., 2022). While transformative teaching is being actively implemented, challenges such as maintaining student engagement in online learning environments and ensuring the effective integration of digital tools remain. Additionally, the success of these educational reforms depends on the student's educators' commitment and students' adaptability to new learning paradigms. The ongoing efforts to enhance academic quality through transformative teaching are crucial for preparing students to thrive in a rapidly changing world.

2. To what extent does transformative teaching enhance critical thinking among Malaysian students?

Transformative teaching has been shown to significantly enhance critical thinking among Malaysian students by incorporating innovative pedagogical strategies that engage students actively in the learning process. This approach is efficient when it integrates problem-based learning, inquiry-based models, and strategic

questioning techniques. The following sections explore how these methods contribute to developing critical thinking skills.

Problem-based learning has been demonstrated to improve critical thinking skills by engaging students in real-world problems that require analytical and evaluative skills. A study involving Malaysian students showed that Problem-Based Learning significantly enhanced their critical thinking abilities, as evidenced by improved test scores in experimental groups compared to control groups (Sartika et al., 2023). The integration of Problem-Based Learning in the curriculum encourages students to explore, question, and apply knowledge, fostering a deeper understanding and critical analysis of the subject matter.

Guided inquiry-based learning models have effectively enhanced critical thinking skills by promoting active student participation and engagement. Studies have shown that students exposed to inquiry-based learning exhibit significant improvements in critical thinking, as measured by N-gain scores and other assessment tools (Ali et al., 2023; Wilatika & Yonata, 2022).

This approach encourages students to ask questions, conduct investigations, and draw conclusions, which are essential components of critical thinking (Ali et al., 2023). Strategic questioning techniques, such as the Problem-Posing Instructional Strategy (PPIS), have been identified as a key method for developing critical thinking skills. This strategy helps students formulate and answer complex questions, enhancing their analytical and evaluative capabilities (Ab.Wahid, 2022).

Transformative teaching also involves redesigning instructional methods to focus on critical thinking. For instance, professional development programs for teachers have been shown to improve their ability to design lessons that foster critical thinking, leading to better student outcomes (Giacomazzi et al., 2023). Blended Project-Based Learning (PjBL) models that integrate 21st-century skills have been found to enhance critical thinking among students significantly. These models combine traditional and digital learning environments, encouraging collaboration and critical analysis (Razak et al., 2022).

While transformative teaching methods have shown promise in enhancing critical thinking, challenges remain in their implementation. For instance, the integration of essential components of thinking into existing curricula can be complex and may require comprehensive program reviews. Additionally, the success of these methods often depends on the teachers' ability to implement and adapt them to their particular educational contexts effectively (Giacomazzi et al., 2023).

3. What is the impact of transformative teaching on student engagement in Malaysian classrooms?

Transformative teaching significantly impacts student engagement in Malaysian classrooms by fostering an environment that encourages active participation, critical thinking, and collaborative learning. This approach enhances students' academic performance and prepares them for future challenges by developing essential skills. The following sections explore various aspects of transformative teaching and its influence on student engagement.

Transformative teaching methods, such as collaborative learning and team teaching, have increased student engagement by promoting active participation and critical thinking. In Malaysian classrooms, cooperative learning has been particularly effective, as it enhances learning outcomes and motivation when students are allowed to choose their group members and receive clear guidance from teachers (Govindarajoo et al., 2023). Integrating literature circles as a pedagogical strategy has also been found to positively influence student engagement by fostering collaborative learning and intrinsic motivation. This approach

encourages students to take ownership of their education and engage deeply with the material (Irwin Talenta & Himawati, 2023).

Teachers' behaviours and emotional intelligence are crucial in shaping classroom engagement. Positive teacher-student relationships and a supportive class atmosphere can significantly enhance students' enthusiasm and participation in learning activities (Sun et al., 2024). The effectiveness of teaching strategies is also linked to the teacher's ability to manage classroom dynamics and provide emotional support, which can lead to improved student engagement and learning outcomes (Liu, 2024). Despite the benefits, challenges such as miscommunication and a lack of student cooperation can hinder the success of transformative teaching methods. Addressing these issues requires careful planning and execution of collaborative activities (Gono & de Moraes, 2023).

Additionally, integrating critical thinking skills into the curriculum is essential for transformative teaching to be effective. However, existing modules may need to be reviewed and updated to fully empower students with these skills (Molotja, 2023). While transformative teaching has shown promising results in enhancing student engagement, it is essential to consider the diverse needs and backgrounds of students in Malaysian classrooms. Tailoring teaching strategies to accommodate these differences can further improve engagement and learning outcomes. Moreover, continuous professional development for teachers can equip them with the necessary skills to implement transformative teaching effectively.

4. What are the primary difficulties and opportunities for adopting transformative teaching approaches in Malaysia's education system?

Adopting transformative teaching practices in Malaysia's education system presents challenges and opportunities. These practices aim to shift from traditional content-based teaching to more dynamic, student-centred approaches that foster critical thinking, creativity, and lifelong learning. Implementing such practices has met with several obstacles, but it also presents potential benefits that could significantly enhance educational outcomes. The COVID-19 pandemic necessitated a shift to online learning, which poses challenges, especially for skill-based subjects like Technical Vocational Education and Training (TVET). The effectiveness of online platforms in delivering practical skills remains questionable, highlighting the need for creative and effective teaching methods (Ab Kadir et al., 2022). Implementing transformative teaching requires teachers to be well-prepared and equipped with the necessary resources. The lack of comprehensive training and resources can hinder the effective adoption of student-centred learning (SCL) and other innovative teaching methods (Bakar & Nordin, 2024; Ramli et al., 2023). The existing educational culture and structure may resist change, as traditional methods are deeply ingrained. As the previous research shows, teachers may face challenges in shifting to a more decentralised and flexible approach, which aims to transform schools through teacher-led initiatives (Istiyarini et al., 2022).

Transformative teaching practices, such as collaborative learning and design thinking, have improved students' learning outcomes, communication skills, and motivation. These methods prepare students for real-world challenges by fostering critical thinking and problem-solving skills (Govindarajoo et al., 2023; Abidin et al., 2022). By focusing on developing students' abilities and encouraging self-reflection and critical thinking, transformative learning can lead to holistic personal growth. This approach aligns with the goals of the Malaysia Education Blueprint to produce well-rounded graduates (Hanaba & Voitiuk, 2022; Ibrahim & Siregar, 2023). Integrating work-based learning (WBL) and 2U2i programs in higher education emphasises

practical, industry-relevant skills, reducing reliance on traditional knowledge and better preparing students for the workforce (Ramli et al., 2023). While transformative teaching practices offer significant opportunities for enhancing Malaysia's education system, they also require overcoming substantial challenges. Addressing these challenges involves ensuring adequate teacher training, resource allocation, and cultural shifts within educational institutions. Embracing these changes can lead to a more dynamic and effective educational environment that meets the needs of the 21st century.

Conclusions

The systematic review of transformative teaching in the Malaysian education sector reveals a significant potential for enhancing critical thinking and student engagement. The findings highlight that transformative teaching, rooted in active, inquiry-based learning, can provide students with the necessary skills to navigate complex and rapidly changing global landscapes. By fostering critical thinking, students are equipped with the ability to analyse, evaluate, and reflect on information, thereby enhancing their academic and personal growth. Similarly, the focus on student engagement ensures that learning becomes an interactive process, where students actively participate in their education rather than passively absorbing information.

In the Malaysian context, the integration of transformative teaching into classrooms remains in its formative stages, particularly in schools where traditional methods such as rote learning and exam preparation still dominate. While efforts have been made to modernise the educational system, such as the initiatives outlined in the Malaysia Education Blueprint (2013–2025), many challenges persist. These include the need for professional development for teachers, who often lack the training and resources necessary to implement transformative teaching effectively. Additionally, the cultural preference for exam-oriented education hinders the broader adoption of transformative pedagogies.

Nonetheless, the opportunities presented by transformative teaching are substantial. With proper institutional support, transformative teaching can be scaled across different educational levels, including primary, secondary, and tertiary education. By encouraging digital tools and platforms, transformative teaching can be integrated into online and hybrid learning environments, enhancing its relevance in a post-pandemic world where digital literacy has become essential. Future research is necessary to explore the long-term impacts of transformative teaching in Malaysia. Studies that track the development of critical thinking and engagement over time will provide valuable insights into the sustained effects of these pedagogical practices. Moreover, exploring how transformative teaching can be adapted to different cultural and socio-economic contexts within Malaysia is crucial for creating more inclusive educational strategies.

In conclusion, adopting transformative teaching offers a promising path for the Malaysian education system. By addressing the challenges and opportunities presented in this review, policymakers, educators, and institutions can work together to foster a more dynamic and critically engaged student population prepared to meet the demands of the 21st century.

References

Ab Kadir, M. N., Ismail, S., & Mohd Shah, N. S. A. (2022). Covid-19: The transformation of learning and teaching for skill-based subject. *International Journal of Academic Research in Progressive Education and Development*, *11*(3). Doi:10.6007/Ijarped/V11-I3/13858

Ab.Wahid, N. T. (2022). Developing critical thinking skills in secondary school students: the potential for strategic management through problem-posing instructional strategy.

International Journal of Academic Research in Progressive Education and Development, 11(3). Doi:10.6007/Ijarped/V11-I3/15505

Abidin, N. Z., Zain, F. M., & Nur, A. H. B. (2022). Development of a design thinking pedagogical model for secondary schools science teachers in Malaysia: A needs analysis. *The Eurasia Proceedings of Educational & Social Sciences, 25*, 133-138. Doi:10.55549/epess.1218215

Ali, A., Rafiqa, R., Palliwi, E. D., Nuraini, N., & Rahmadiani, R. (2023). Implementing guided inquiry-based biology learning tools to enhance students' critical thinking skills. *Jurnal Penelitian Pendidikan IPA, 9*(6), 4856–4862. Doi:10.29303/Jppipa.V9i6.4541

Ali, A., Rafiqa, R., Palliwi, E. D., Nuraini, N., & Rahmadiani, R. (2023). Implementing guided inquiry-based biology learning tools to enhance students' critical thinking skills. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4856–4862. Https://Doi.Org/10.29303/Jppipa.V9i6.4541

Ayub, E., Lim, C. L., Yeo, D. C. H., & Ismail, S. R. (2022). Developing a solution for hybrid classroom: A pilot study from a Malaysian private university. *Frontiers In Education*, 7. Doi:10.3389/Feduc.2022.841363

Bakar, N. H. A. & Nordin, M. N. (2024). Inclusive education programs in Malaysia: teachers' challenges in implementation. *Special Education* [Se], *2*(1), e0017. Doi:10.59055/Se.V2i1.17

Giacomazzi, M., Serwanga, E., & Atuheire, G. (2023). Transforming teachers' instructional design for enhancing critical thinking in Ugandan schools. *Gile Journal of Skills Development*, *3*(1), 15–39. Doi:10.52398/Gjsd.2023.V3.I1.Pp15-39

Gono, S., & De Moraes, A. J. (2023). Student appraisals of collaborative team teaching: a quest for student engagement. *Journal of Applied Learning and Teaching*, *6*(1), 222–233. Doi:10.37074/Jalt.2023.6.1.26

Govindarajoo, V., Aboudahr, S., & Yee, C. Y. (2023). A case study on the implementation of collaborative learning in the Malaysian lower secondary classroom. *International Journal of Academic Research in Progressive Education and Development*, *12*(2). Doi:10.6007/Ijarped/V12-I2/16826

Hadi, T., & Batara Marpaung, A. (2023). Transformational leadership and knowledge management impact on organisation performance: A systematic review. *International Journal of Social Service and Research (IJSSR)*, *3*(1), 1978-1986.

Hanaba, S., & Voitiuk, O. (2022). Heuristic Potential of Transformative Learning Ideas. *Pedagogika-Pedagogy*, *94*(1), 19–30. Doi:10.53656/Ped2022-1.02

Ibrahim, N., & Siregar, E. (2023). The epistemology of transformative learning: A systematic instructional design framework model in transformative learning. *International Journal of Multi Discipline Science*, *69*(1), 18. Doi:10.26737/ij-mds.v6i1.3545

Irwin Talenta, P., & Himawati, U. (2023). Reading Together Learning Together: The Impact Of Literature Circles On Student Engagement In Reading. In Jurnal CULTURE (Culture, Language, And Literature Review), *10*(2), 47-56. Doi:10.53873/culture.v10i2.538

Istiyarini, P., (2022). Guru penggerak and transforming schools withing the framework of appreciative inquiry. *Internationall Proceedings of Nusantara Raya*, *1*, 316-323.

Kant, S. (2023). Transformational leadership effect on organisational performance in Ethiopia public sector: Systematic literature review. *Studies In Economics And Business Relations,* 4(1), 31–44. Doi:10.48185/Sebr.V4i1.745

Liu, S. (2024). The impact of teaching strategies and style on classroom engagement and interaction of elementary school students. *Journal of Education, Humanities and Social Sciences, 26,* 1087-1092. DOI:10.54097/ny24px49

Molotja, T. W. (2023). Enhancing Students' Engagement And Critical Thinking Skills In English Language Teaching: A Transformative Approach. *International Journal of Membrane Science and Technology*, *10*(4), 952-956.

Nur Rohmah, A., Julia Sari, I., Lailatur Rohmah, N., Syafira, R., & Admoko, S. (2022). Implementation of the "Merdeka Belajar" curriculum in the Industrial 4.0 Era. *International Journal of Research And Community Empowerment*, *1*(1), 22–28. Doi:10.58706/ijorce.v1n1.p22-28

Omodan, B. I., & Addam, B. (2022). Analysis of transformational teaching as a philosophical foundation for effective classrooms. *Journal of Curriculum Studies Research*, *4*(2), 15–29. Doi:10.46303/Jcsr.2022.9

Page, M. J., Mckenzie, J. E., Bossuyt, P. M., … Moher, D. (2021). The Prisma 2020 Statement: An Updated Guideline For Reporting Systematic Reviews. In *Plos Medicine* 18(3). Doi:10.1371/Journal.Pmed.1003583

Pathurohman, P., Berger, M., & Michael, G. (2023). Implementation of hybrid learning to maintain the quality of learning in fostered MTS during the Covid-19 pandemic. *At-Tasyrih: Jurnal Pendidikan dan Hukum Islam*, 8(2), 96–104. Doi:10.55849/Attasyrih.V8i2.139

Paul, J., Lim, W. M., O'cass, A., Hao, A. W., & Bresciani, S. (2021). Scientific procedures and rationales for systematic literature reviews (Spar-4-Slr). *International Journal Of Consumer Studies, 45(5).* Doi:10.1111/Ijcs.12695

Ramli, S.., Omar, F., Dolah, J., Yasin S. S. N. A, & Jusof, M. J. (2023). 2u2i and WBL-Based programs student-centered learning efficacy in Malaysian Higher Education. *PUPIL: International Journal of Teaching, Education and Learning*, 4(3), 62–79. Doi:10.20319/Dv4.6279

Razak, A. A., Ramdan, M. R., Mahjom, N., Zabit, M. N. M., Muhammad, F., Hussin, M. Y. M., & Abdullah, N. L. (2022). Improving critical thinking skills in teaching through problem-based learning for students: a scoping review. in international journal of learning, *Teaching and Educational Research,* 21(2), 342–362. Doi:10.26803/Ijlter.21.2.19

Sartika, W., Rahman, S. R., & Irfan, M. (2023). Empowering students' critical thinking skills using problem-based learning. *Inornatus: Biology Education Journal*, 3(2), 67–74. Doi:10.30862/Inornatus.V3i2.427

Subedi, A., & Sherpa, D. (2022). Transformation of Social And Pedagogical Behaviours of University Teachers in the COVID-19 Pandemic. *International Journal of Multidisciplinary Research and Growth Evaluation,* 3(5), 433-437. Doi:10.54660/anfo.2022.3.5.19

Sun, Y., Zhou, G., & Deng, X. (2024). Emotional intelligence and joyful teaching: pathways to enhanced student engagement and achievement. *Lecture Notes in Education Psychology and Public Media*, 52(1), 163–168. Doi:10.54254/2753-7048/52/20241533

Wilatika, R. A. S., & Yonata, B. (2022). Implementation of guided inquiry learning model to exercise students critical thinking skills on reaction rate material. *Jurnal Pijar MIPA*, 17(1), 34–40. Doi:10.29303/Jpm.V17i1.3241

Zahari, N., & Kaliannan, M. (2023). Antecedents Of Work Engagement In The Public Sector: A Systematic Literature Review. *Review of Public Personnel Administration*, 43(3), 557–582. Doi:10.1177/0734371x221106792

Adopting Immersive Technology in Automotive Vocational Education: A Comprehensive Review

Nur Syadhila Che Lah*[1], Hafizan Mat Som[1], Luqman Hakim Mohd Roslan[2], Amzari Jihadi Ghazali[3]
[1] Universiti Teknologi PETRONAS, Malaysia.
[2] Kolej Komuniti Bagan Datuk, Perak, Malaysia.
[3] Kolej Professional MARA Seri Iskandar, Malaysia.
*nursyadhila.chelah@utp.edu.my

Introduction

The automotive industry is rapidly advancing with the rise of automation, electrification, and innovative technology integration. To keep pace with these developments, vocational education must prepare students with the skills and competencies that align with industry needs. However, traditional training methods often lack the flexibility and realism required for simulating complex automotive tasks. Immersive technology presents a promising alternative, enabling interactive, hands-on learning experiences that closely mirror real-world scenarios. This review examines the latest trends, advantages, challenges, and prospects of integrating immersive technology into automotive vocational training.

Literature Review

Immersive technology holds considerable promise in education because it can create interactive, simulation-based learning experiences. Research indicates that VR and AR can significantly boost student engagement and motivation by offering realistic simulations that reinforce hands-on skills. For example, virtual reality (VR) simulations enable students to safely practice complex automotive repairs and diagnostics, while AR overlays provide real-time, step-by-step guidance for mechanical tasks. This technology aligns with experiential learning theories, highlighting learning through experience as an effective way to build practical skills (Kolb, 2014).

VR enables immersive, simulated environments to replicate real-life automotive scenarios, allowing students to engage in otherwise costly, time-consuming, or risky activities. According to Radhakrishnan et al. (2021), VR simulations expose automotive students to complex machinery and vehicle systems without needing actual physical vehicles. Students can repeatedly practice tasks such as engine assembly, diagnostics, and repairs, thus improving both their procedural knowledge and motor skills. Research also demonstrates that VR reduces training time by enabling students to quickly and effectively learn standardised automotive procedures (Chiang et al., 2022).

Augmented reality (AR), which overlays digital information onto the physical world, provides real-time assistance in automotive training. Studies reveal that AR applications can guide students in executing tasks with precision, making them especially valuable for intricate procedures requiring high accuracy (Wang et al., 2021). AR applications have been developed to help students understand complex components by displaying layered visuals, allowing students to visualise cross-sections and functional mechanisms within automotive parts (Lee et al., 2022). Additionally, AR has been found to reduce cognitive load by offering timely instructions and reducing dependency on written manuals.

Mixed reality (MR) combines elements of VR and AR, creating immersive environments where students can interact with digital and physical objects. MR provides unique applications in automotive education, such as holographic engines and mechanical parts that students can manipulate and examine from various angles. Mallek et al. (2024) demonstrated that MR could enhance learning by combining virtual simulations with physical equipment, allowing students to simultaneously apply theory and practice in hybrid environments.

Research Methodology

This study used PRISMA-guided methodology to provide a structured and transparent approach to analysing how immersive technology transforms automotive vocational education, with rigorous adherence to inclusion criteria, quality assessment, and thematic analysis. The following detailed steps are applied, starting with defining how immersive technologies (virtual, augmented, and mixed reality) have been adopted in automotive vocational education, focusing on pedagogical benefits, challenges, and outcomes. The scope is limited to studies conducted from 2018 to 2023, ensuring the analysis covers recent advancements and practices. The inclusion criteria include studies focusing on VR, AR, or MR in the context of automotive vocational education and research articles presenting empirical data, case studies, or reviews that provide insights into immersive technology's application, effectiveness, or challenges in vocational settings. However, the exclusion criteria have disregarded the studies of non-English publications, which are not explicitly related to automotive vocational education. The extracted data is synthesised to provide a comprehensive overview, which includes the trends in frequency and type of immersive technologies used, as well as shifts in adoption over time. The benefits of learning outcomes, skills enhancement, student engagement, and cost-effectiveness are considered in this study. The study also identified the limitations, such as high implementation costs, technical barriers, and requirements for instructor expertise. Next, the future outlook covers the gaps and suggestions for future research directions, such as broader skills assessment and the need for longitudinal studies.

Result and Discussion

In the context of automotive education, immersive technology offers a unique opportunity to bridge the gap between theoretical knowledge and hands-on skills required in real-world scenarios. Research indicates that the successful implementation of immersive technology in automotive education relies on thorough curriculum design and integration. Studies emphasise the importance of designing VR and AR modules that complement existing training frameworks, covering diagnostics, procedural training, and safety protocols. For example, one study found that using AR for engine diagnostics allowed students to visualise internal mechanisms while receiving real-time guidance, enhancing understanding compared to textbook-based methods (Phakamach et al., 2023).

Empirical research underscores the necessity of instructor training and institutional support. Studies reveal that instructors are more likely to use immersive technology effectively if they receive structured training and ongoing support. Additionally, institutions that provide resources like dedicated VR/AR labs or integration support see higher levels of technology utilisation. The case studies from institutions implementing VR and AR reveal several best practices, including phased implementation, collaborative projects with industry partners, and adaptive assessments tailored to immersive learning environments. For instance, research on automotive training programs that partner with VR/AR tech providers often reports smoother implementation and better outcomes due to

tailored training resources and shared goals. Besides that, previous studies consistently cite high upfront and maintenance costs as primary limitations in VR/AR adoption. This particularly impacts automotive programs with limited funding, which may struggle to afford the latest immersive tech. Despite the educational benefits, research suggests that financial constraints limit widespread adoption. One of the primary barriers to implementing immersive technologies is the cost of hardware, software, and specialised training. The need for high-quality VR headsets, AR devices, and the development of customised automotive simulations can be prohibitively expensive for many vocational institutions (Swargiary & Roy, 2022).

Studies also reveal that a lack of technical support and inadequate infrastructure, such as limited access to high-speed internet and advanced hardware, can impede the effectiveness of immersive training programs (Ayomide, 2022). Additionally, not all vocational schools have the resources to maintain these technologies. The success of immersive technology in education depends on the ability of instructors and students to use the tools effectively. Many instructors lack the training to integrate VR, AR, and MR into their teaching methods, while students accustomed to traditional training may require time to adjust to these new modalities (Philippe et al., 2020). Quality and Content Availability: While VR, AR, and MR applications are advancing, the content available for automotive education is still limited. Developing high-quality simulations and content that align with specific automotive skills and competencies requires substantial investment and research (Sonal et al., 2024).

Conclusion and Future Recommendations

Empirical research on the adoption, implementation, and outcomes of immersive technology in automotive education highlights the transformative potential of VR/AR in enhancing student learning and skill acquisition. Future research could explore adaptive VR and AR systems that personalise learning experiences based on each student's skill level and learning pace. By adjusting the difficulty of simulations or offering tailored feedback, immersive technology can enhance individualised learning. Studies suggest the potential for VR and AR to be used in training, assessment, and certification. By integrating immersive technology into examinations, institutions can assess students' real-time problem-solving skills and procedural accuracy in simulated environments (Fitrianto & Saif, 2024). Most studies to date focus on short-term learning outcomes. Long-term studies are needed to evaluate how immersive technology impacts retention, transfer of skills, and job performance in real-world automotive settings. Future research could investigate how immersive technology can be applied across various fields within automotive education, such as electric vehicle systems, autonomous vehicle diagnostics, and smart car technologies.

Acknowledgement

We want to acknowledge the grant funder, Short Term Internal Research Funding (STIRF- 015LA0-066), Universiti Teknologi PETRONAS, for funding this research paper and publication.

References

Kolb, D. A. (2014). Experiential learning: Experie*nce as the source of learning and development*. New Jersey: FT Press.

Radhakrishnan, U., Koumaditis, K., & Chinello, F. (2021). A systematic review of immersive virtual reality for industrial skills training. *Behaviour & Information Technology*, 40(12), 1310- 1339.

Chiang, F. K., Shang, X., & Qiao, L. (2022). Augmented reality in vocational training: A systematic review of research and applications. *Computers in Human Behavior*, 129, 107125.

Wang, Z., Bai, X., Zhang, S., Wang, Y., ... & Li, J. (2021). The role of user-centred AR instruction in improving novice spatial cognition in a high-precision procedural task. *Advanced Engineering Informatics*, 47, 101250.

Mallek, F., Mazhar, T., Shah, S. F. A., Ghadi, Y. Y., & Hamam, H. (2024). A review on cultivating effective learning:synthesizing educational theories and virtual reality for enhanced educational experiences. *PeerJ Computer Science,* 10, e2000.

Swargiary, K., & Roy, K. Exploring the Role of Virtual Reality in India's Education System: A Review of Current Applications and Future Prospects. system, Doi::10.13140/RG.2.2.12900.76164/1

Ayomide, D. D. (2022). Application of virtual reality for enhanced learning integration in higher education institutions. Thesis, University of Johannesburg, South Africa.

Philippe, S., Souchet, A. D., … Coldeboeuf, G., & Duzan, H. (2020). Multimodal teaching, learning and training in virtual reality: a review and case study. *Virtual Reality & Intelligent Hardware*, 2(5), 421-442.

Sonal, G., Israrul, H. M., & Ganesh, S. (2024). Human Skills in the Era of Industry 4.0 in the Indian Automotive Industry. *Abhigyan,* 42(2). Doi:10.1177/09702385241235459

Fitrianto, I., & Saif, A. (2024). The Role of Virtual Reality in Enhancing Experiential Learning: A Comparative Study of Traditional and Immersive Learning Environments. *International Journal of Post Axial: Futuristic Teaching and Learning*, 97-110.

Phakamach, P., Panjarattanakorn, D., Saengkaew, P., Pangthai, S., & Onsampant, S. (2023). Innovative Practices in Vocational Education Administration. *International Journal of Educational Communications and Technology*, *3*(2), 1-19.

Innovative Learning: Leveraging Chatgpt in Engineering Coursework Through The Samr Framework

Iskandar Dzulkarnain*, Chee Wee Sia
Universiti Teknologi PETRONAS, Malaysia
*iskandar_dzulkarnain@utp.edu.my

Introduction

In the rapidly evolving landscape of education, integrating advanced technological tools is paramount to enhancing student learning and engagement. The SAMR (Substitution, Augmentation, Modification, and Redefinition) model provides a robust framework for incorporating technology into teaching practices, enabling educators to transform traditional instructional methods and create more dynamic learning environments. This paper explores the innovative application of ChatGPT, an AI language model, within the SAMR framework to support and enhance engineering coursework. While research on integrating AI in higher education has seen a dramatic increase in recent years, the potential of ChatGPT, a generative AI tool within the SAMR framework, particularly in Petroleum Engineering courses, remains unexplored. This lack of exploration prompts the current study to answer the following research question: How does the integration of ChatGPT through SAMR in Reservoir Engineering I coursework affect the students' achievement, particularly in attaining the Third Course Learning Outcome (CLO3).

As the course material consists of four-course learning outcomes (CLO), we focus only on CLO3, where the coursework associated with this outcome has been modified and redefined as per SAMR. Rather than evaluating the student's understanding of this CLO through the usual quiz or test, the students now prepare group video projects discussing technical papers related to topics covered under the CLO. The technical papers were sourced from the Society of Petroleum Engineering (SPE) conference proceedings. ChatGPT was integrated during the students' preparation of the video content.

Literature Review

In recent years, the integration of AI in higher education has emerged as a growing trend. The development of ChatGPT by OpenAI represents a significant advancement in generative AI. ChatGPT is a chatbox system based on generative AI that uses Natural Language Processing (NLP) to give its ability to generate highly coherent written content that closely resembles human-created texts.

Pham et al. (2023) investigate the benefits and challenges of using ChatGPT – 3.5 as a learning tool in an engineering course. Although they recognise its benefits, the authors suggest that interested instructors adopt a systematic learning workflow approach when integrating ChatGPT into their teaching and learning processes. They also emphasise the need to guide and train students to interact effectively and appropriately with ChatGPT. Puig–Ortiz et al. (2024)we evaluated the effectiveness of ChatGPT in supporting students' learning in

the Mechanism and Machine Theory (MMT also evaluate the effectiveness of ChatGPT in supporting students' learning in a Mechanical Engineering course. While they acknowledge its versatility in supplementing students' learning, they noted that the answers provided by ChatGPT were not always clear. Therefore, the authors recommend that instructors emphasise critical thinking among their students when using the tools, not as a substitute for their intellectual efforts.

Although many studies have explored the integration of AI into teaching and learning, a systematic approach to its implementation remains lacking. The SAMR framework, introduced by Dr Ruben Puentedura, provides a structured model to guide instructors in the progressive incorporation of AI into pedagogy (Hamilton et al., 2016). In brief, the framework divides the technology integration into Substitution, Augmentation, Modification, and Redefinition. A recent study by Muslimin et al. (2024) an AI-powered tool, integration across SAMR (Substitution, Augmentation, Modification, and Redefinition illustrated AI integration into their English as First Language (EFL) coursework. In the context of Petroleum Engineering instruction, the present study details the integration of ChatGPT AI into Reservoir Engineering I teaching through the SAMR framework.

Research Methodology

The present study aimed to evaluate the students' Course Learning Outcome 3 (CLO3) achievement in Reservoir Engineering I. This is done by integrating the application of ChatGPT in the coursework. The coursework for this CLO has been modified and redefined according to the SAMR. The study involved 14 participants taking this course in May 2024. The participants were students from the second year of the Bachelor of Petroleum Engineering program at Universiti Teknologi PETRONAS (UTP). The age range of the participants was between 20 to 21 years old.

Previously, the assessment for this CLO was done through quizzes or test questions. In line with the SAMR framework, the students must read technical papers related to the CLO material and prepare a group video presentation to discuss the contents. Each group uploaded the videos to YouTube. The project briefing was conducted in the middle of the 12-week semester, and students were explained the necessary tools to complete the project, with ChatGPT as one of the tools. The assessment was done through a rubric developed to score the video content. The results were analysed by comparing the attainment of CLO3 with the previous cohort (September 2023) through non-parametric statistical analysis.

Results and Discussion

The videos developed by each group and uploaded to YouTube are shown in Figure 1.



No.	Link
1.	https://youtu.be/6KmQMZBN-kU?si=FLHbVGk1GT_rQ1PC
2.	https://youtu.be/AIX5a_uIhdk?feature=shared
3.	https://youtu.be/hyHr0ZPdp5Y

Figure 1 Videos from Reservoir Engineering 1 group projects

Three videos were uploaded to YouTube, each representing the groups of 14 students taking this course in the May 2024 semester. The duration of each video ranges from eight to 20 minutes. In each video, group members take turns narrating the summaries of the technical paper by providing audio and visual descriptions.

The instructor evaluated the videos using a rubric developed for this study. The rubric assessed the five categories of concept, design, participation, final product, and audio–video

quality; and credits/references across the range of excellent (5 points), good (4 points), satisfactory (3 points) and needs improvement (1 – 2 points) for a total of 20 points.

The results were compared with the previous cohort taking this course in September 2023 to reveal significant differences in CLO3 achievement. The descriptive statistics for the two groups are shown in Table 1 and Figure 2.

Table 1 Group descriptives of two cohorts showing achievement of CLO3

	Group	N	Mean	Median	SD	SE
CO3	SEPT23	57	64.2	64.9	12.9	1.70
	MAY '24	14	80.8	72.5	14.2	3.79

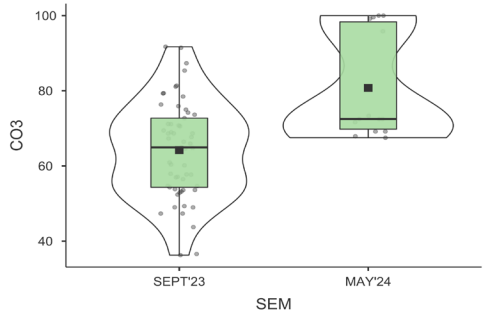


Figure 2 Box and violin plots showing the mean and median scores in CLO3 for two cohorts

The descriptive statistics show that the group that undertook the coursework project involving the group video presentation achieved better CLO3 scores, as evidenced by the mean and median.

To confirm whether the results are statistically significant, we compare the mean scores of the two groups in an independent samples T-test. Since the number of students comprising each group was different, and the results were not normally distributed, a non-parametric test using Mann – Whitney U was performed. The results are shown in Table 2 and Figure 3.

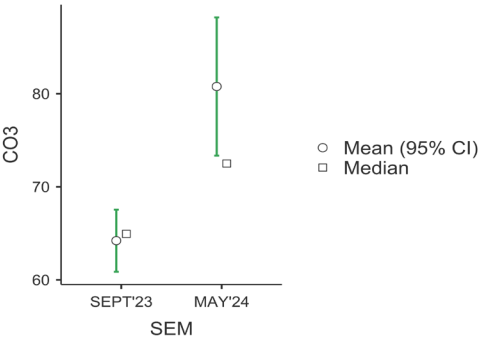


Figure 3 Comparison of CLO3 achievement between two cohorts

The mean score for CLO3 in the May '24 cohort was 80.8% (SD = 14.2), whereas the mean in the September '23 cohort was 64.2% (SD = 12.9). The Mann-Whitney U test indicates that the mean difference was significant. $(t(71)=163, p<.001, CI_{95}=[-24.2,-6.56])$, suggesting that a genuine difference in learning outcomes has occurred.

An example of students' feedback is shown in Figure 4. The students documented their workflow in the input to complete the project with ChatGPT integration. The tool effectively summarises the content of the technical paper and helps students outline and organise their

Table 2 Results of independent samples T-test

					95% Confidence Interval	
		Statistic	p	Mean difference	Lower	Upper
CO3	Mann- WhitneyU	163	<.001	-15.5	-24.2	-6.56

Note: $H_a\ \mu_{SEPT'23} \neq \mu_{MAY'24}$

presentations. This enabled them to expedite the content creation process and allowed them to focus on understanding the material and showing their understanding through the video creation.

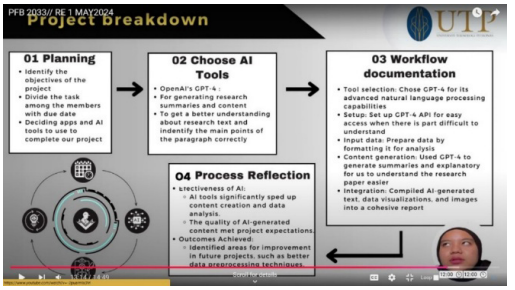


Figure 4 Student feedback showing how the group integrates ChatGPT in their video preparation

Conclusion

The study has demonstrated the impact of integrating ChatGPT to improve students' achievement of course learning outcomes through group projects structured according to the SAMR framework. The results indicate improvement in CLO3 achievement compared to the previous cohort. The students' feedback also reflects a positive impact when using the tool while completing their project. Overall, the study provides valuable insights and guidance for instructors seeking to harness the power of AI in their teaching practices. The findings underscore the importance of thoughtful integration to ensure that AI tools enhance the learning experience.

Acknowledgement

The authors would like to acknowledge the financial support from the Department of Petroleum Engineering, UTP, for participating in TLIF 2024.

References

Hamilton, E. R., Rosenberg, J. M., & Akcaoglu, M. (2016). The Substitution Augmentation Modification Redefinition (SAMR) Model: A Critical Review and Suggestions for its Use. *TechTrends,* 60(5), 433-441.

Muslimin, A. I., Nur, M., & Francisca Maria, I. (2024). Evaluating Cami AI across SMAR Stages: Students' achievement and perceptions in EFL writing instruction: Cami AI-SAMR in EFL Writing Instruction. *Online Learning*, 28(2).

Pham, T., Nguyen, T. B., Ha, S., & Ngoc, N. T. N. (2023). Digital transformation in engineering education: Exploring the potential of AI-assisted learning. *Australasian Journal of Educational Technology*, 39(5), 1-19.

Puig-Ortiz, J., Pàmies-Vilà, R., & Nebot, L. J. (2024). Exploring the application of Chatgpt in Mechanical Engineering Education. 51st Annual Conference of The SEFI, Dublin.

Podcast Production Role-Play: Enhancing Peer Collaboration by USIM Learning Communities

Ainurliza Mat Rahim*, Dini Farhana Baharudin
Universiti Sains Islam Malaysia
*ainurliza@usim.edu.my

Introduction

To engage students in meaningful and purposeful learning, the lecturer initiated a collaborative approach that leveraged two distinct groups of students as integral resources in the learning process. Thus, students were assigned a podcast production role-play in Semester II, Academic Session 2023/2024, to simulate producing a podcast. Table 1 below summarises the designated structure of collaborative work between two groups.

This pedagogical strategy draws on High-Impact Educational Practices (HIEPs) principles, which advocate for students' engagement through innovative and experiential learning activities (Ministry of Higher Education, 2020). The collaboration combined several novel components reflective of HIEPs, as illustrated in Figure 1.

Literature Review

As educational practices continue to evolve, paragogy has emerged as a key component in addressing the demands of 21st-century skills, such as collaboration, communication, and critical thinking (Kuh, 2008). Paragogy, rooted in social constructivist theories, emphasises

Table 1 The Structure of collaborative work in podcast production

	Programme	Course Title	Year of Studies	Learning Outcome Domain	Role Assignment
1.	New Media Communications	AEN2063 Social Media Culture	Second Year	Cognitive Domain (PLO2-Cognitive Skills)	Host(s) Guest(s) Researcher Scriptwriter Editor Marketer
2.	Communication	AEN2093 Practices of Citizen Journalism	Third Year	Affective Domain (PLO5-Communication Skills)	



Figure 1 Peer collaboration model in podcast production

that learning is an active, socially driven process shaped by shared experiences and group interactions. It encourages students to assume collective responsibility for their learning, with each individual contributing knowledge and insights (Corneli et al., 2020).

Recent research underscores the effectiveness of paragogy in enhancing student engagement, collaboration, and self-directed learning. Davis & Francis (2021) suggest that paragogy promotes conceptual understanding and nurtures essential soft skills. Furthermore, the post-pandemic shift in education has increased the emphasis on collaborative learning models prioritising co-determination, wherein students and educators work together to shape the learning experience (Amiruddin et al., 2023; Azorín & Fullan, 2022).

In Malaysia, paragogy has garnered significant interest within higher education institutions. Samsudin et al. (2022) identify paragogy as a practical collaborative pedagogical approach, particularly in entrepreneurship education, where students collaborate to construct knowledge, solve problems, and meet learning objectives. Similarly, paragogy has been implemented in mathematics (Suhaimi et al., 2021) and architectural education (Noor, 2019). There is a noticeable gap in the literature, as paragogy has yet to be explicitly examined or acknowledged within the field of media and communications. This study, therefore, analyses the collaborative experiences through a podcast production role-play to unveil the strengths and outcomes of peer learning in media and communication studies at USIM.

Methodology

This research applies thematic analysis to analyse group reflections and peer evaluation data. Thirteen students from AEN2093 Practices of Citizen Journalism were combined with 21 students from AEN2063 Social Media Culture. They were divided into six groups, each with students from both subjects. The collaborative effort took rigorous steps, as outlined in Figure 2.

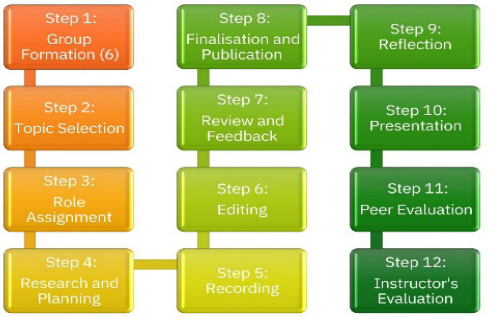


Figure 2 Twelve steps of collaborative assignment in podcast production

In analysing written reflections (Step 9), thematic analysis allows for identifying key themes related to the learning process and challenges encountered (Terry et al., 2017). Furthermore, thematic analysis was applied to the open-ended responses of peer evaluations (Step 11), where students assessed each other's contributions and performance. By coding these responses, researchers can identify common perceptions of fairness, effort, and effectiveness of teamwork.

Result and Discussion

Upon completing the recording and editing phases of the podcast project, each group composed a reflective assessment, which they then submitted to the USIM learning management system. In the final week, students engaged in a peer evaluation of group performance via Microsoft Forms. Each group member assessed all other members, including a self-evaluation, using a Likert Scale (1 to 4) across commitment, contribution, and competency criteria. The peer evaluation score for everyone was determined by calculating the average score assigned by fellow group members.

The findings derived from the thematic coding of written reflections underscore the complexity and richness of group dynamics in collaborative learning environments. The key theme of collaboration is consistent with existing literature on group learning, which suggests that effective collaboration is essential for fostering deep learning and achieving positive educational outcomes (Johnson & Johnson, 2018). The identification of communication breakdowns aligns with studies emphasising the challenges inherent in group work, particularly when students from diverse academic backgrounds are brought together (Chan et al., 2022). These issues of miscommunication, while potentially disruptive, offer opportunities for students to engage in problem-solving and conflict resolution, making them more interactive in groups; as pointed out by Chan & Cho (2022), collaborative communication is the key to encountering problems and eventually leads to creative product performance.



Figure 3 The key themes

Further, the peer assessment data revealing themes of leadership, accountability, and participation discrepancies reflect the significance of individual roles within group work. Research by Bastea et al. (2023) highlights the importance of distributed leadership in group settings, where individual members take responsibility not only for their contributions but also for the success of others. Discrepancies in participation, a common issue in group-based learning (Boud et al., 2001), reveal underlying tensions that often surface during collaborative projects. Addressing these discrepancies requires a balanced approach that encourages both autonomous contribution and collective responsibility, further supporting the development of skills crucial for professional practice, such as accountability and adaptability (Oakley et al., 2004).

The collaborative efforts between the two subjects effectively enhanced the students' competencies and quality characteristics.

Conclusion

Aligned with high-impact educational practices (HIEPs), sustainable development goals (SDGs), and the importance of quality education, the finding shows that peer collaboration is instrumental in promoting active learning and improving student outcomes. By integrating subjects, students were empowered to engage in more profound levels of education, fostering creativity, critical thinking, and problem-solving. This collaborative model sets a precedent for innovative educational practices in media and communications, potentially influencing future curricular designs and prioritising cross-disciplinary partnerships.

Acknowledgement

Thank you to USIM Radio for providing students with the facilities to record their podcast programs.

References

Amiruddin, Baharuddin, F. R., Takbir, Setialaksana, W., & Nurlaela. (2023). Andragogy, peeragogy, heutagogy and cybergogy contribution on self-regulated learning: A structural equation model approach. *International Journal of Instruction*, *16*(3), 551-572.

Azorín, C., & Fullan, M. (2022). Leading new, deeper formsof collaborative cultures: Questions and pathways. *Journal of Educational Change*, *23*(1), 131-143.

Bastea, A.-R., Catalano, H., & Ionela, A. D. (2023). An overview of distributed leadership and its shortcomings in educational settings. *Educatia 21*, 114-126.

Boud, D., Cohen, R., & Sampson, J. (2001). *Peer Learning in Higher Education: Learning from and with Each Other*. London: Routledge.

Chan, C. W. F., Hafiz, M., Siu, Y. H., Tu, F., Siu, S. S. Y., Lam, J. L. K., Snell, R. S., & Yue, K. K. M. (2022). The developmental impacts of interdisciplinary and inter-institutional service-learning collaboration. In Ngai G. & Shek, D. T. L. (eds.), *Service-Learning Capacity Enhancement in Hong Kong Higher Education* (pp. 239–255). Springer.

Chan, H. M. H., & Cho, V. W. S. (2022). An empirical study: The impact of collaborative communications on new product creativity that contributes to new product performance. *Sistainability*, *14*(8), 4626.

Corneli, J., Danoff, C. J., Ricaurte (2020). *The Peeragogy Handbook*. Third Edition. Chicago: PubDomEd and Pierce Press.

Davis, B., & Francis, K. (2021). Peeragogy (paragogy; peer learning; peer teaching; peer to peer learning). *Discourses on Learning in Education. https://learningdiscourses.com.*

Johnson, D. W., & Johnson, R. T. (2018). Cooperative learning: the foundation for active learning. In S. M. Brito (ed.), *Active Learning: Beyond the Future*. London: IntechOpen.

Kuh, G. D. (2008). *High-Impact Educational Practices: Whatthey Are, Who Has Access to Them, and Why They Matter*, Washington DC: AAC&U

Ministry of Higher Education (MoHE). (2020). *High-Impact Educational Practices (HIEPs): The Malaysian Higher Education Experience*, Volume 2, Putrajaya: MoHE.

Noor, M. Z. M. (2019). The future of architectural education in Malaysia: Introducing a new theory of audiology using the SOLE module. In E. Salleh & R. Powell (eds.), *The Future of Architectural Education + Practice in Malaysia*. Kuala Lumpur: Pertubuhan Arkitek Malaysia.

Oakley, B., Felder, R. M., & Brent, R. (2004). Turning student groups into effective teams. *Journal of Student Centered Learning*, *2*(1), 9-34.

Samsudin, N., Ramdan, M. R., Zakaria, T., & Aziz, N. A. A.(2022). The role of heutagogy, peeragogy, and cybergogy in entrepreneurship education: A preliminary review. In S. Adam & N. Mhd Fuzi (eds.), *Enterpreneurship & Business Management: Practice, Process, Theory* (pp. 20–28). Skudai: UTM Press.

Suhaimi, N. A., Tajudin, N. M., Adnan, M., Puteh, M., & Yerizon. (2021). Ke arah kurikulum tersedia masa hadapan melalui pengajaran berasaskan pendekatan paragogi. *Jurnal Pendidikan Bitara* UPSI *14* (Special Issue), 41-50

Terry, G., Hayfield, N., Clarke, V., & Braun, V. (2017). Thematic analysis. In C. Willig & Wendy Stanton Rogers (eds.), *The SAGE Handbook of Qualitative Research in Psychology*, Second Edition, (pp. 17-37), Los Angeles: Sage.

Transformative Teaching and Learning in Service Learning (SULAM) Approach

Adzidah Yaakob*, Dina Imam Supaat, Abidah Abdul Ghafar, Nurfadhilah Che Amani, Suraiya Osman, Fadhlina Alias
Universiti Sains Islam Malaysia (USIM)
*adzidah@usim.edu.my

Introduction

The Service-Learning Malaysia–University for Society (SULAM) approach in Environmental Law for law students represents a transformative teaching and learning method that integrates academic knowledge with real-world environmental challenges. By blending theoretical coursework with community engagement, the SULAM (JPT, 2019) approach encourages students to apply legal concepts to address pressing environmental issues, fostering intellectual growth and social responsibility. This method transforms traditional legal education into an experiential process, enabling students to learn environmental protection laws and contribute actively (Merzel, 2023) to sustainable practices and policy development. It cultivates a deeper understanding of environmental stewardship and equips future legal professionals with the practical skills and ethical foundations necessary to advocate for environmental justice. Carta Alir Mudahnya SULAM CAMS is an infographic flowchart in the form of a structured approach to implementing SULAM activities to aid in reference and understanding of the Environmental Law course. This is especially true when students demonstrate the ability to apply campus knowledge, think critically and creatively to identify the local community's needs, and effectively communicate with the community during SULAM projects. Students using the experiential learning technique in SULAM activities must be committed to participating in organised service projects that address the needs of the designated community or organisation while meeting the course's learning objectives.

SULAM as a transformative teaching and learning in legal education

The concept of transformative teaching and learning in legal education, particularly in environmental law, is grounded in pedagogical theories that emphasise the role of education in fostering critical thinking, ethical awareness, and active learning. Scholars such as Jack Mezirow (1997) have discussed transformative learning as an educational approach that challenges students to critically examine their beliefs, assumptions, and experiences, enabling them to develop a deeper understanding of complex societal issues. In environmental law, this approach is increasingly essential for preparing law students to address the multifaceted legal, social, and ecological challenges posed by environmental degradation and climate change.

As an extension of transformative pedagogy, service learning connects academic coursework with community service. This approach has mainly influenced environmental law education, allowing students to apply legal theory to real-world environmental issues.

According to Eyler and Giles (1999), service learning fosters a stronger sense of civic responsibility among students, bridging the gap between legal knowledge and social impact. In environmental law, service-learning enables students to collaborate with non-governmental organisations, governmental agencies, and local communities to address pressing environmental concerns. This experiential component deepens students' understanding of legal frameworks and promotes a sense of environmental stewardship and public advocacy.

Furthermore, transformative teaching in environmental law is characterised by an interdisciplinary approach. Environmental law intersects various fields, including science, economics, and politics. Educators who adopt a transformative approach encourage students to think beyond the legal sphere (Merzel, 2023), integrating knowledge from these diverse fields to develop a comprehensive understanding of environmental issues. Boyd (2014) highlights that such interdisciplinary perspectives are crucial for addressing the complexities of environmental law, as legal professionals must often navigate scientific uncertainty and conflicting economic interests in their work.

The transformative potential of these teaching and learning methods in environmental law education is widely recognised for its ability to prepare law students as competent legal professionals and advocates for environmental justice and sustainability. However, challenges remain in the implementation of such approaches. These include balancing the theoretical and practical components of the curriculum, ensuring access to diverse and meaningful experiential learning opportunities (Slavic, 2012), and addressing the resource limitations many law schools face. Despite these challenges, the growing body of literature on transformative teaching and learning in environmental law underscores its importance in shaping the next generation of legal professionals equipped to address our time-pressing ecological problems.

The infographic flowchart "Carta Alir Mudahnya SULAM (CAMS)"- A teaching and learning tool

Carta Alir Mudahnya SULAM (CAMS) is a structured infographic flowchart designed to facilitate reference and understanding of the Environmental Law Course using transformative teaching and learning employing SULAM activities. This innovative teaching and learning tool (CAMS) has successfully guided two cohorts of students in designing and producing 29 SULAM modules: 16 modules and 13 modules, respectively. Another accomplishment is that CAMS has already registered with the Copyright Act and received four stars in MyRA's recognition. CAMS was also awarded a Gold Medal at the Putra Innocreative Poster Competition, International Putra Innocreative Carnival in Teaching and Learning 2023. CAMS has been shared with the faculty members to be adapted in their teaching and learning depending on the course's suitability.

The chronological sequence of activities in CAMS can be seen as follows.

This flowchart is designed to streamline the planning, implementation, and evaluation of SULAM activities. It makes it easier for educators and students to follow a structured approach to community engagement and experiential learning. It provides a step-by-step guide from initial planning to execution and assessment, ensuring effective collaboration and learning outcomes.

Step 1: Identify Agency/Community
The process begins with identifying and selecting a suitable agency or community for the course lecturer. Coordination with the faculty is essential at this stage. Before the semester starts, it is important to brief the chosen agency or community about the program's objectives, expectations, and anticipated outcomes.



Figure 1 Carta Alir Mudahnya SULAM (CAMS)

Step 2: Preparation of Budget Paper
Once an agency or community has been identified, the lecturer will prepare a budget paper. This document should outline all anticipated costs and detail any resources or support required from the faculty to facilitate the program's success.

Step 3: Evaluation of Rubric and Instructions
The course lecturer prepares an evaluation rubric to ensure that students have clear guidelines and assessment criteria. This rubric helps students understand the tasks and expectations for their involvement in the SULAM program.

Step 4: Guided Module Drafting and Group's Budget
Following the evaluation rubric, the students create a draft module and a budget plan. This draft provides a preliminary program structure, including activities, timelines, and additional budgetary needs. It should be reviewed and refined by the second week of the semester.

Step 5: Module Presentation
Once the draft is finalised, the students present the module to the course lecturer. This module serves as a reference guide, providing detailed instructions and expectations for student participation in SULAM activities.

Step 6: Final Preparation
Final preparations ensure that all materials, tools, and resources are available and ready. This step ensures that students and faculty are adequately prepared for the upcoming SULAM activities.

Step 7: Module Implementation
The module is then implemented according to the activity plan. During this stage, students engage in hands-on learning experiences, working closely with the agency or community and applying their developed knowledge and skills.

Step 8: Student Evaluation and Reporting
After completing the module, students are evaluated using the pre-established rubric. A final report in a specified format is also submitted, summarising the program's outcomes, student reflections, and any insights gained from the SULAM activities.

The impact of CAMS on transformative teaching and learning

The Environmental Law Course students have successfully designed and prepared using CAMS. All 29 SULAM modules through a series of in-person and online discussions led by the course lecturer. The modules, designed for elementary school pupils, focused on environmental awareness and environmental legal literacy, such as Green Scape Mansion. Eco-Bingo, Sweet Forest, Recyclorun, Dumpster Dash, Let's Treasure 5R, Earthquest: Eco-Challenge, Mock Environmental Court, Dart Poaching and others. These modules can be seen as the culmination of transformative teaching and learning, which equips the next generation with the skills, values, and knowledge necessary to become responsible citizens who will build environmentally conscious and sustainable communities. Another benefit is the pursued community, which is the school pupils' ability to respond to the environmental challenges addressed in the modules. Additionally, schoolchildren are exposed to crucial environmental stewardship problems, including technology, safety, and health, which causes a shift in perspective and heightened awareness. Cooperation and networking have been strengthened by involving several government and private agencies. This shows continuous collaboration opportunities for leveraging USIM's expertise within the local community.

Conclusion

In conclusion, the transformative approach to teaching and learning in environmental law represents a paradigm shift in legal education. Integrating experiential learning through SULAM, interdisciplinary perspectives, and critical pedagogy enhances students' legal knowledge and fosters a deeper understanding of environmental law's social and ethical dimensions. As the world's ecological challenges become increasingly complex, the need for intellectually adept and socially conscious legal professionals has never been greater. Transformative teaching and learning in environmental law by employing innovative tools, i.e., CAMS, provide a crucial foundation for developing such professionals, ensuring they are prepared to navigate ecological protection and sustainability's legal and ethical challenges.

Acknowledgement

We want to express our sincere gratitude to the Centre of Excellence in Teaching and Learning (CeTL) and the Faculty of Syariah and Law (FSU), Universiti Sains Islam Malaysia (USIM), for their invaluable support and funding in the development of CAMS (Carta Alir Mudahnya SULAM). Our most profound appreciation also goes to our colleagues and assessors for their continuous guidance and feedback, which were instrumental in refining this project. We are grateful for the permission granted to publish our findings and share CAMS with a broader educational community, contributing to the advancement of SULAM pedagogy.

References

Adzidah, Y, Dina, I.S, Abidah, A.G, Fadhlina, A, Nurfadhilah, C.A & Suraiya, O. (2023). Carta Alir Mudahnya SULAM (CAMS). No. Pemberitahuan: CRLY2024W04962. Akta Hak Cipta 1987, Putrajaya: Jabatan Peguam Negara Malaysia.

Boyd, D. (2014). *The Environmental Rights Revolution: A Global Study of Constitutions, Human Rights, and the Environmen*t. Vancouver: UBC Press.

Eyler, J., Giles, D., & Astin, A. (1999). Where's Learning in Service-Learning? *The Journal of Higher Education*, 72(2), 256-258.

JPT (Department of Higher Education). (2019). *SULAM Playbook*, Putrajaya: Malaysia.

Mezirow, J. (1997). Transformative Learning: Theory to Practice. *New Directions for Adult and Continuing Education*, 74, 5-12.

Merzel, C. R. (2023). Pedagogy for Transformative Teaching and Learning. *Pedagogy in Health Promotion*, 9(4), 231-233.

Slavich, G. M., & Zimbardo, P. G. (2012). Transformational Teaching: Theoretical Underpinnings, Basic Principles, and Core Methods. *Educational Psychology Review*, 24(4), 569-608.



e ISBN 978-967-2880-84-4