Introduction

> ❝ *I hear, and I forget. I see, and I remember. I do, and I understand*
> Adapted from Confucian philosopher Xunzi, *c*250BCE

What is simulation? What is a simulator?
What does it mean to 'simulate' something?

The Merriam-Webster dictionary defines 'simulation' as: *the imitative representation of the functioning of one system or process by means of the functioning of another*, such as *a computer simulation of an industrial process)*. It also defines a simulator as: *a device that enables the operator to reproduce or represent under test conditions phenomena likely to occur in actual performance*. To 'simulate' is: *to give or assume the appearance or effect of…*

In his book, *Simulations: A Handbook for Teachers and Trainers*, Ken Jones suggests that the dictionary definition is a bit misleading, since it describes the event in the simulation as not real but pretence or play-acting on the part of the participants in a structured theatrical environment.

A well-designed training event using simulation as a tool within a structured simulated training environment encourages participants to go beyond play-acting and requires professional behaviour. Simulation is a learning environment that provides a sense of realism, with a focus on skills, attitudes and behaviours or feelings related to the session.

ⓘ INFORMATION
Global Maritime Education and Training (GlobalMET) www.globalmet.org
International Conference on Engine Room Simulators (ICERS)
www.imla.co/committees/icers.htm
International Marine Simulator Forum www.imsf.org
International Maritime Lecturers Association (IMLA) www.imla.co
International Navigation Simulator Lecturers' Conference (INSLC)
www.imla.co/committees/inslc.htm
International Simulation and Gaming Association (ISAGA) www.isaga.com

While simulation can, and often is, used for purposes other than education, including research, validation of processes and the concept of 'digital twins', this handbook focuses on providing skills for the simulation instructor to facilitate learning.

In maritime education and training, there are a number of organisations devoted to furthering the role of simulation training and developing these tools. In the 1970s,

the International Marine Simulator Forum (IMSF) was established to contribute to improvements in maritime simulation and to provide a forum for interchange of ideas and experiences. The International Maritime Lecturers Association (IMLA) concentrates on maritime education and training. It has established two sub-committees that specifically address maritime simulation aspects: the International Navigation Simulator Lecturers Conference (INSLC – established in 1980) and the International Conference on Engine Room Simulators (ICERS – established in 1993).

Simulation is not a new idea. Throughout the centuries, apprenticeship training has been used to enable experts to pass on their knowledge to others. The tools used in these apprenticeships could be real, or could be mock imitations to enable the apprentice to try out the skills in a safe, controlled manner. The use of a simulator, or simulated activities, enables this apprenticeship-style approach to be used effectively in a learning environment.

What must be realised is that simulators are, in their essence, simply another training aid that is available to facilitate learning. Therefore simulation is not, in itself, an instructional technique but an activity that is used within an overall training programme.

For the purposes of this handbook, the following definitions are used:

Simulator: the tool. *A working representation of reality; it may be an abstracted, simplified or accelerated model of the process. For training events, it allows participants to explore systems and scenarios where reality is too expensive, complex, dangerous, fast or slow.* There can be different types of simulator: full-mission (replicating the work environment in high-fidelity), part-task (focusing on specific elements) or low-level (designed to address a specific purpose or subset of the work environment).

Simulation: the activity. *The use of a simulator, or simulated activity, to enable the effective transfer of knowledge, skills and attitudes.*

Simulation instructor: *someone who uses the simulator for training. The simulation instructor may also be referred to as a simulator trainer.*

Formally defined, a training aid is any device, equipment, machine, mock-up, illustration, simulator or other mechanism used to improve or support the teaching and learning process. Training aids can help participants achieve objectives by activating one or more of the five senses (sight, sound, smell, taste and touch). To be effective, however, training aids must be effectively integrated into a training programme.

This is where the role of the simulation exercise, as well as that of the instructor designing and running the exercises, becomes important. Simulators, when properly used, can be one of the most effective teaching methods to transfer knowledge from theory to practical application.

Types of training aid

The list of training aids is only limited by the imagination, and can include:
- Workbooks, manuals, programmed texts
- Books, articles, pamphlets, newspapers
- Models, real objects, mock-ups, specimens
- Photographs, maps, charts, diagrams, pictures, drawings
- Slides, presentations (e.g. PowerPoint)
- Audio, sound files
- Films, videos
- Computer programs, multimedia presentations
- Simulators

Generally, training aids fall into one of these four broad categories:

a. **Visual** relates to what a person sees, or perceives to see. Visual training aids include devices used primarily to reproduce visual stimuli, with or without motion (photographs, slides, flip charts, boards, videos, replays, maps, charts).

b. **Aural (auditory)** relates what a person hears, or perceives to hear. Auditory training aids include devices used primarily to reproduce sound (recordings, replays).

c. **Verbal (linguistic)** relates to the use of words and linguistic skills. Verbal training aids include sound files to replay, reviews, word games and role-play.

d. **Physical (kinesthetic)** relates to a person's awareness of positions and movement. Kinesthetic training aids include devices that allow for the practice of actions and reactions, involving the use of the body or limbs (manipulation of tools).

i **INFORMATION**
Simulator
A working representation of reality.

A simulator, the tool that provides the working representation of reality, is primarily a kinesthetic training aid that allows for manipulation in a realistic environment. However, one of the main strengths of simulation is that it combines all categories of training – with a focus on visual, audio and kinesthetic – which makes it a very strong and powerful training aid.

Over the years, and with increasing computing power, simulators in maritime education and training have evolved to provide high-quality visuals with realistic sound and motion. The famous *Star Trek* simulation 'Kobayashi Maru', which was designed to have no resolution (a no-win scenario), is possible. Yet, what will the participant learn about the real work environment if every simulation is designed in such a manner to make optimum use of the tools (the simulator) but does not necessarily incorporate sound teaching approaches?

_i_ **INFORMATION**
Andragogy
The art and science of helping adults learn (Malcolm Knowles).

In addition, in many instances of maritime education and training (MET) the most appropriate training approach is not found in the traditional pedagogical training methodologies – an approach that is more suited for use with children and youths. In fact, the term 'pedagogy' itself literally means 'lead the child'. MET participants, at all levels, are post-high-school or university graduates, so instructors need to ensure that the unique requirements of the adult learner are addressed. This means the approach needs to address the adult, or 'andragogy', as presented in many adult learning approaches, based initially on Malcolm Knowles' work. When using simulators in a learning environment, instructors need to ensure that the approach to developing and running simulation training exercises and scenarios meets specific criteria and that the overall learning event encourages participants to realise the full benefit of the experiential learning cycle.

This edition of _A Simulation Instructor's Handbook_ has been developed and revised based on many years of practical experience using simulators in training environments, as well as discussion and feedback from other simulation instructors. It is primarily intended as a resource for instructors expected to design and implement simulation training. It does not touch on the design of the equipment itself, nor does it cover the operation of the many varied simulators available. Noting that simulators can also be effective assessment tools, this edition includes an extended section on the use of simulation in assessment and evaluation.

No matter what type or level of simulation you use, it is hoped that some aspect of this handbook will be adaptable to your environment.

For easy reference, the handbook includes boxes highlighting key concepts within the text, as well as handy tips and resources where you can find more information. At the time of publishing, all web addresses included are in operation.

Each section of the handbook concludes with a summary, confirmation of learning and resources that can be reproduced or adapted for use.

_i_ **INFORMATION**
CPD www.nautinst.org

The Nautical Institute is pleased to promote exchanges of views and experiences in simulation training, through its technical library and online forums, linked from The Nautical Institute's website. Through shared experiences and best practices in simulation training, it is hoped that future editions of this handbook can be revised to reflect changing needs of simulation instructors.

Part 1

Deciding training needs

The objectives of Part 1 are for the reader to:
- Identify five different instructional techniques
- Link the use of simulation to instructional techniques
- Identify three levels of simulation
- Link simulation levels to training requirements
- List five simulator instructor competencies

Tools for reproduction or adaptation are:
- Table 1 – Linking instructional techniques and learning goals
- Figure 1 – Teaching techniques and learner participation
- Generic skill-sets for simulation instructors

Some specific terms in Part 1 include:

Andragogy: (*an·druh·goh·jee*) The art and science of helping adults learn

Asynchronous learning: Refers to learning 'apart' in a delayed time frame. This is where learners access materials at their own pace without real-time interaction with the instructor and other learners

Competence: The ability to perform a job effectively, efficiently and safely

Didactics: The science of teaching, educating and training with a view to imparting knowledge, skills, experiences and attitudes. Relates to autodidactics, or self-education (self-learning)

Experiential learning: A method of teaching that utilises active participation with the applied use of new skills through the provision of an 'experience', such as role-play, simulation and on-the-job experience

Gamification: Applying gaming designs and concepts to learning scenarios (resulting in more engaging or entertaining training interventions)

Heutagogy: (*heeyoot·a·goh·jee*) From the Greek for 'self'. Defined by Hase and Kenyon in 2000 as the study of self-determined learning (rooted in andragogy)

Instructional techniques (or strategies): The methods, techniques or tools that can be used to assist the learner to understand and interact with the content being presented

Pedagogy: (*peh·duh·goh·jee*) From ancient Greek, literally translated 'to lead the child'

The immediacy and relevance of training can be addressed by being fully conversant with the workplace – the environment in which the worker spends each working day. If training interventions can use these three elements – understanding of the work, the worker and the workplace – then effective transfer of theory to practice can take place.

1.1.1 Adult learning theory

When approaching programmes for MET, it is important to move away from the pedagogical approaches used in primary and secondary schools, and instead reflect the adult learning approaches as identified by Malcolm Knowles in his work on andragogy. Adult learners have a strong sense of self and need to know why the learning is required and how it immediately affects their work. This need for immediacy and relevance is fundamental to developing training interventions for adult learners.
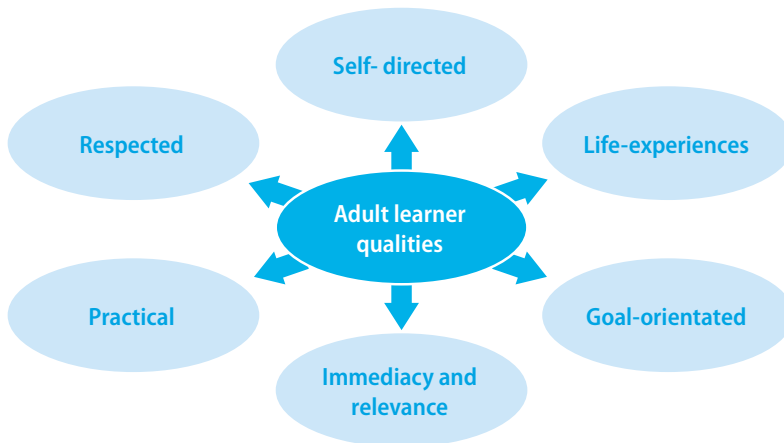
Traditionally, there are different considerations when approaching the training for children (pedagogy) and adults (andragogy). As education theory continues to evolve, many elements of adult learning are now being brought into training programmes for young adults and children.

Children	Adults
Providing knowledge foundation, developing critical thinking skills	Have base of existing knowledge and life experience
Usually 'no choice' – have to go to school, may not be engaged	Need to understand why they are learning, high engagement and motivation
Teacher 'in charge' of the classroom	Learner-centric approach
Teachers deliver knowledge	Facilitator/instructor supports learning

1.3.5 Games and gamification

Games have been a means to enhance learning for centuries. The development of computerised games, indeed the concept of computer simulation and gaming, is prevalent in education and our homes. Looking specifically at the role of games in learning environments, the role of the instructor is to plan (or identify) the game, construct the rules for play, initiate the game and monitor its progression. The use of games requires the instructor to adapt to changing situations, especially when the game progresses differently from what was expected. A debriefing session following the game is necessary to anchor knowledge and identify areas where additional learning would be valuable.

Gamification of different learning activities provides opportunities for individual and small-group learning using a training application or tool. This can be an effective approach to progressing learning for participants at different levels, promoting self-directed learning.

Advantages: Games create a fun and lasting learning experience, facilitate group learning, encourage critical thinking and provide structure to informal learning opportunities.

Disadvantages: May require significant effort to plan. Explanation of the goal and process may be misunderstood and introduce variables that could lead to unexpected results. Some game applications may not be directly related to the objective, and this could lead the instructor to revise the objective to fit the game, which may detract from the overall learning opportunities.

Link to simulation: Direct. Some games may use part-task simulation, providing a direct link to the simulation activity. Games may also be used to support or focus on areas that require further development for the participant to better succeed in the simulation.

1.3.6 Demonstration of skill and behaviour modelling

Learning a skill implies a process that includes acquiring and processing information (cognitive activity), using repetition to increase efficiency (psychomotor activity) and translating the information into co-ordinated action (joining cognitive and psychomotor activity). The instructor, by actually performing a specified task or job, shows others what to do, how to do it and, through explanations, brings out why, where and when it is done. The participant is then required to practise the same task under the supervision of the instructor. In this way, the instructor can monitor, coach and correct the participant as the performance is being learned and mastered. The instructor can also ensure that safety procedures are being followed and reduce the chance of accidents.

In a similar vein, behavioural modelling involves the process of having a model or ideal enactment of a desired behaviour presented in some manner – instructor, videotape or film. Participants are then put in a situation where they can practise the behaviour that was modelled.

Advantages: Enables confirmation of correct performance of a specific skill and can assist with building a skill-set by breaking a process down into steps.

Disadvantages: Instructor must be able to demonstrate the skill or behaviour correctly, or participants will learn bad habits from them.

Link to simulation: Direct. The simulator provides a working representation of reality in which to demonstrate skills and model behaviours. This teaching technique lends itself to all levels of simulation.

HANDY TIP

'EDIC' – Steps of a skill lesson

Explain

Present an overview of the skill to be performed and the context in which it should be carried out. Provide the knowledge needed to understand what is involved in the skill and how to perform it.

Demonstrate

The demonstration can concentrate on one part of the skill, or the entire skill, depending on complexity. The demonstration must also consider any safety concerns, as well as previous skills and competence. The instructor demonstrates the operation as many times as required and then invites the participant to practise. It is important that the demonstration is not rushed and that participants have an opportunity to ask questions.

Imitate

The participants practise or perform the skill while the instructor provides coaching, if required. If the skills are complex and safety-critical, the participants could be asked to describe the procedure with the instructor performing the task according to the participants' directives.

Confirm

The instructor provides feedback and reinforcement, so participants know how well they are progressing. A skill test can also be used to confirm performance.

1.3.7 One-on-one and on-the-job training (OJT)

This is when an instructor works one-to-one with a participant. In this situation, the participant can observe and question the instructor while the skill or knowledge is being taught and can receive guidance and coaching from the instructor. OJT may be carried out during a work activity, under supervision. In a more generic learning environment, a group tutorial or one-on-one session can be used to emulate an OJT approach.

Thanks to the development of e-learning, there is an opportunity for teaching, tutoring or coaching to be synchronous (learning together, in real time) or asynchronous (learning apart, at different times). Some computer-based simulation tools may provide interactive
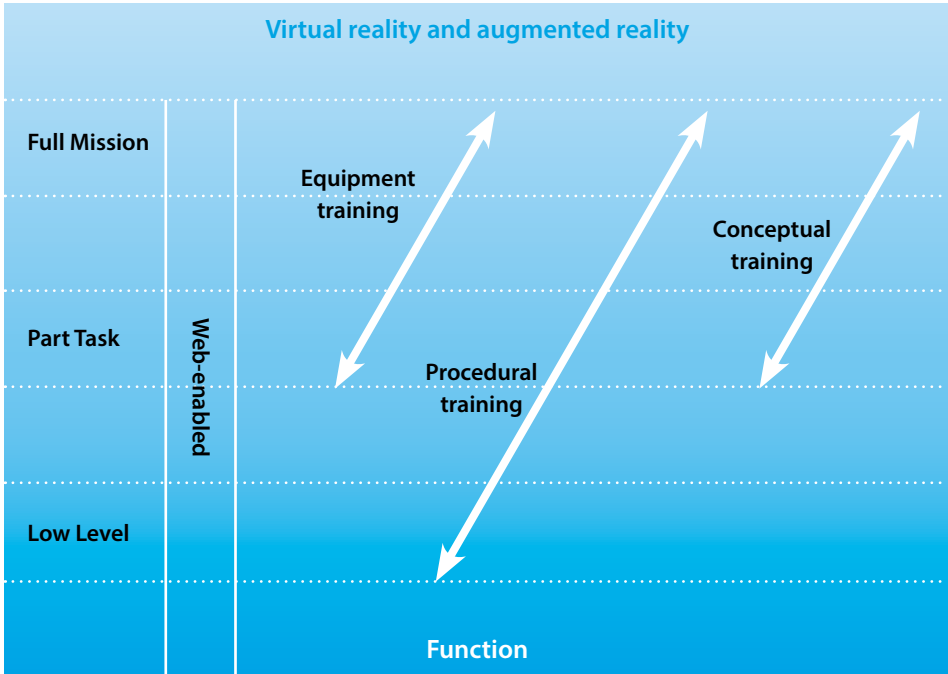
Figure 2: Types of simulator function

1.7 Role of the instructor

> *The best teachers coach their students and the best coaches are great teachers*
> Grant Teaff

What is the role of the instructor in a simulated environment? The traditional concept of a lecturer at the front of the class does not apply, so we need to rethink the traditional concept of the instructor.

Simulation instructors may be chosen for their on-the-job expertise. They may or may not have experience of formal teaching or learning. If they do have training experience, it is likely to be in a more traditional classroom setting, using training aids and instructional techniques suited to that setting. The simulator is simply another training aid, albeit a specialised and often quite sophisticated one. The integration of simulation training within a learning programme requires focused skills and knowledge of how simulations can support the learner to achieve the most effective results.

1.7.2.4 Subject matter knowledge

Depending on the equipment used, simulation instructors may need additional specific skills – for example, those skills related to the type of hardware and software being used in a computer-based simulator.

It is likely that specific skill-sets will be required, such as strong field expertise and a sound knowledge base of the workplace that is being simulated. These specific skills enable the instructor to provide the sense of realism – ensuring the training is up to date and relevant to the real world. As the world is changing rapidly, it makes sense to have a few core simulation instructors with rotating field personnel.

1.8 Simulator staffing options

When setting up a simulator, the teaching staff must be carefully considered. Who will design the exercises? Who will run the simulator? Who will teach in the simulator? Who will provide technical support for the simulator tools? Various approaches can be taken, depending on the expertise and funding that is available and on the stated need for the training.
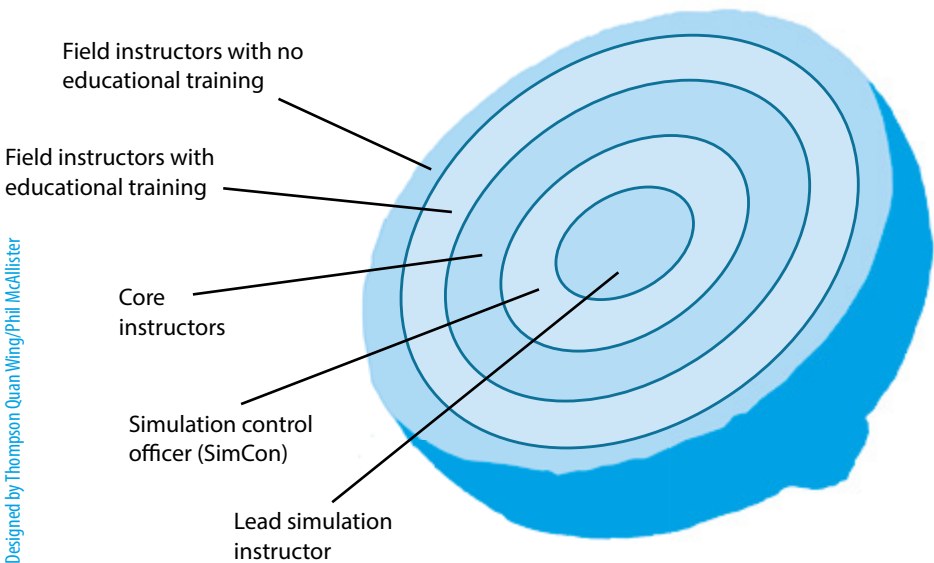

Field instructors with no educational training

Field instructors with educational training

Core instructors

Simulation control officer (SimCon)

Lead simulation instructor

Designed by Thompson Quan Wing/Phil McAllister

Figure 3: An onion model for simulator centre staffing

So, it's a good start, but not an entirely effective learning objective. Let's try again…

In a 15-minute simulated activity, the participant will construct ten VTS messages using standard phraseology with a maximum of two errors.

Performance (*What?*)	Condition (*How?*)	Standard (*How well?*)
Construct ten VTS messages using standard phraseology	In a 15-minute simulated activity	Maximum of two errors

Specific	Measurable	Achievable	Realistic	Time-bound
Yes	Yes	Yes	Yes	Yes

The revised example meets all five SMART criteria.

2.3.2 Learning taxonomies

A taxonomy is a grouping or classification of something. A learning taxonomy is a way to describe certain types of learning or behaviours – related to cognitive, affective and psychomotor. Within each of these 'domains' there are action verbs that can be used to develop SMART objectives. See Section 2.9.1 for different taxonomies and their associated action verbs.

Over the decades, several taxonomies have been developed, related to each of the domains. These include:
● **Bloom (revised):** Focusing on the cognitive domain
● **Krathwohl:** Focusing on the affective domain
● **Dave:** Focusing on the psychomotor domain

There are other developments in taxonomies, including Marzano's taxonomy, considered as an alternative to the revised Bloom taxonomy (focuses on the cognitive, with elements of the affective domain through a focus on critical thinking), and the SOLO (Structure of Observed Learning Outcomes) taxonomy from Biggs and Collins. The SOLO taxonomy presents a systematic approach to describing how a learner's performance grows when mastering tasks.

All taxonomies look at the concept of lower-level and lower-order learning outcomes to more complex, or higher-order, outcomes. These are often referred to as LOTS (lower-order thinking skills) and HOTS (higher-order thinking skills).

The development of objectives will reflect the learning process from LOTS to HOTS within the SMART objective framework.

Through use of the different taxonomies, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) has created a five-level taxonomy that could be suitable for use in simulation training environments.

preparation of the simulator, the simulation exercise and the learning environment will enable both instructors and participants to concentrate on the actual simulation and not on any ancillary elements that, while not directly related to the simulation, could cause frustration or reduce the opportunity for learning.

HANDY TIP

Before starting the exercise, be certain that the planned simulation for the session is prepared and technically correct. The simulation activity within the simulator (low-level, part-task or full-mission) should be ready to run within the software. If there is any indication that the system is not functioning properly, check the technical aspects, restart the simulator and reload the simulation to improve the chances of a trouble-free session.

Noting that technical issues will undoubtably arise at some time during the training programme, it is also important to build in flexibility to address situations where simulation may not work as expected or the simulation activity needs to be rescheduled.

3.1.3 Providing the learning environment

As with all learning, the environment within and around the simulator must be conducive to learning. The basic needs of human beings were reflected by Abraham H Maslow in his hierarchy of needs. Training environments must address the basic needs in order for learning to occur.
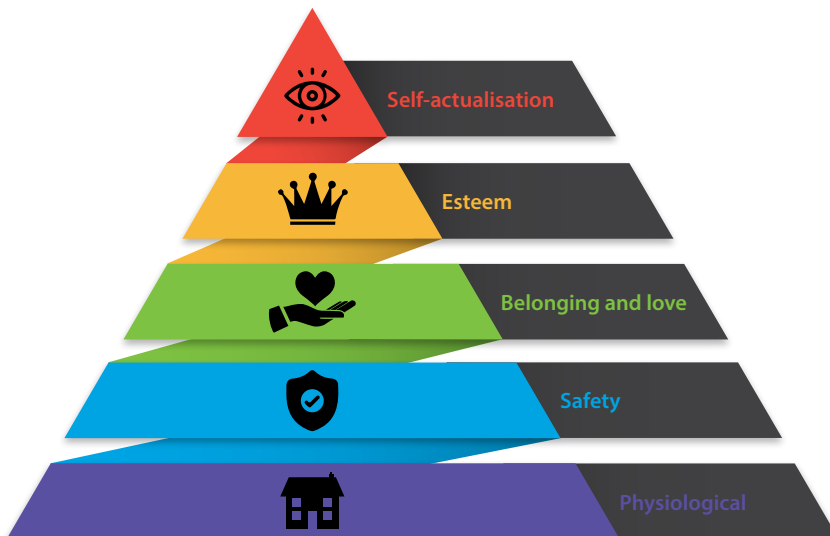

Figure 7: Maslow's hierarchy of needs