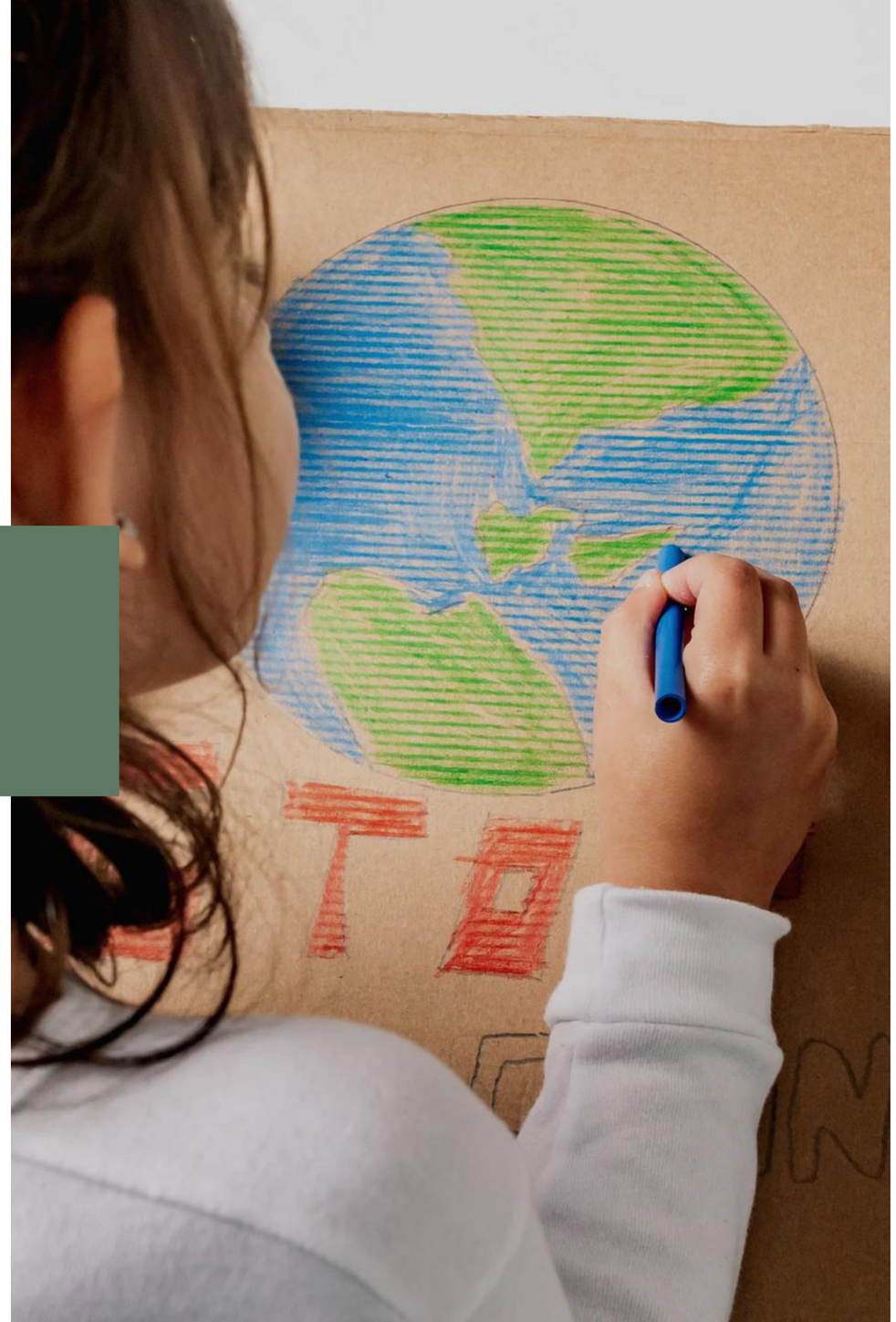

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Wi-Mi

Pedagogical strategy

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Content

"IF WE DESTROY NATURE, NATURE WILL DESTROY US"

WANGARI MAATHAI

Co-funded by
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Chapter 1

Climate change and science

Introduction

We are becoming more and more aware of environmental issues and their impact on our societies and everyday life. Teachers strive to form informed and active students, who will work and build with nature, instead of apart from it. However, the educational potential of nature-based solutions (NBS) remains largely unexplored, while innovative programs and resources around NBS are currently lacking in formal and informal education programs for children and families.

This material aims to bridge that gap by exploring the implementation of nature-based solutions in classrooms through ready-to-use learning activities. The learning activities presented in this material promote critical thinking, collaboration and project-based learning and can be easily adapted to a range of subjects. Furthermore, these activities include proposals for online implementation.

Climate change is a major global issue that affects the environment, our communities and our personal lives. Although the climate has always changed, the current human-induced climate change is unusual in the speed at which it is occurring. This raises the question of whether we can still do something about climate change. In this chapter, we will take a closer look at the causes and consequences and solutions to climate change. After implementing knowledge and activities during class, students will know a lot about climate change and its consequences!

Climate change is important because it affects the Earth's natural systems and the way people live. Increasing temperatures lead to more frequent heat waves, droughts and natural disasters such as hurricanes and fires. These events can have serious consequences for human health, agriculture and the economy.

"It has been clear for decades that the Earth's climate is changing, and the role of human influence on the climate system is undeniable." That's what Valérie Masson-Delmotte of the Intergovernmental Panel on Climate Change says.

Teaching natural sciences and climate change

If we decided to include global climate change in the curriculum, where would it fit? The possibilities are numerous, and the teacher who chooses to include the question will find ways to adapt it. Some caution is needed based on students' levels of mental functioning: concrete versus abstract understanding. Elementary school children under the age of 10, as well as many older ones, are not at the appropriate levels of cognitive development to effectively deal with the dimensions of space and time encompassed by the term climate as opposed to daily time. The ozone hole in particular is an intangible idea that should be avoided at an early age to prevent confusion with weather experiences. There are some tangible experiences that can demonstrate the greenhouse effect, but overall the key concepts for understanding climate change are very abstract and beyond the mental preparation of elementary school students. More instruction will not change student readiness based on level of cognitive development. Some of the more obvious curriculum choices for secondary science schools, with examples, are:

Teaching natural sciences and climate change - I

- Biology/life sciences: carbon cycle, producer species, effects of environmental conditions on living things (surrogate data such as goads, coral strips, etc.), physical requirements of habitats, influence of previous climates in Earth's history. Students can study how climate change can disrupt ecosystems and affect and will continue to affect biological life cycles, called phenology.
- Chemistry: changes in water quality related to quantity (dilution); precipitation analysis, CO2 sources and testing, soil analysis, insulating properties of CO2. Students can study how ocean acidification results from the absorption of excess CO2 from the atmosphere into seawater and can have major impacts on marine life. They can also study how climate change affects agriculture by reducing arable land.
- Physics: light spectrum, heat versus temperature, density and distribution of gases, mechanism of the greenhouse effect, energy calculations, atmospheric and oceanic movements, etc. Changes in atmospheric gas composition already affect the flow of energy and matter around the Earth. Students can investigate how these shifts affect the absorption and release of solar radiation and the effects of warming on ocean currents.
- Earth/Space Science: atmospheres of other planets, Earth's historical climates, ice ages, climate, atmospheric and oceanic movements, geographic relationships, land vs. water in energy relationships, basis for supporting life, proxy data from fossils and ice cores, natural contributions such as volcanic emissions, etc. Geographic information systems and computer models are the main tools for modeling the impact of climate change on a global scale. Students can analyze existing models and create their own (eg in Google Maps). It is important that students understand the carbon cycle process.
- Environmental Science: (not the usual curriculum, but full of possibilities) analysis of issues, components of viewpoints, issues of science and society, economics of decisions, etc.

Teaching natural history and climate change - II

Students need to be aware of the fact that these changes affect us all and that the effects of climate change on our personal lives may vary depending on where you live and your personal circumstances. Some potential consequences of climate change for individuals include:

Climate change causes extreme weather: Climate change can lead to more frequent and severe extreme weather events, such as heat waves, droughts, floods, hurricanes and wildfires. These events can cause damage to homes, businesses and infrastructure, and can also pose a risk to human health (sources: European Commission, IPCC).
Climate change affects our health: Climate change can affect human health in a number of ways, such as increasing the risk of heat stroke, respiratory problems and infectious diseases. It can also affect the availability and quality of food and water (source: World Health Organization).
Climate change affects our economy: Climate change can have an economic impact on individuals and communities, such as the cost of damage from extreme weather events, the cost of adapting to changing conditions and the loss of income from agriculture and other industries affected by climate change (source: European Environment Agency).
Climate change affects our mental health: Climate change can also have social and psychological effects on individuals, such as stress and anxiety caused by extreme weather and other impacts of climate change (source: World Health Organization).

Teaching natural history and climate change - III

Many believe that including subjects related to climate change in the school curriculum will help young people cope more easily with the reality of global warming, both practically and psychologically. A global study last year found that climate concerns affect the daily lives of almost half of young people. The research, carried out by the University of Bath, was based on a survey of 10,000 young people in 10 countries - 75% of respondents said international bodies called for climate change studies to be taught in schools as a formal part of the curriculum. The United Nations says it should be part of the curriculum in all schools by 2025. A UNESCO study analyzed curriculums in nearly 50 countries and found that more than half did not mention climate change. Only 19% mentioned biodiversity. American think-tank Brookings claims that greater environmental awareness in schools will lead to changes in consumer behavior, with reduced energy consumption and waste. He says this would have a greater impact on the effort to reach net zero by 2050 than investing in renewable energy such as wind turbines and solar power.

One thing is certain: science is best learned by doing. When we allow our bodies to become part of the learning process, we understand better. We believe that reading about a concept in a textbook or even watching a demonstration in class is not the same as physically experiencing what you are learning about.

Why is science important?

Science education gives students the opportunity to gain a better knowledge of how and why things work. Science can teach children about the world around them. From human anatomy to transportation techniques, science can reveal the mechanisms and reasons behind complicated systems.

Science is everywhere, so it plays a major role in teaching global change in the classroom. In school curricula in most parts of the world, science subjects are divided into physics, chemistry and biology, and the connections between these areas are usually not emphasized. Science students should be encouraged to develop their sense of curiosity and gain the confidence to ask questions and challenge assumptions. Science students should be familiar with our world and aware of how nature works. They should also think analytically and quantitatively, keep an open mind and remain independent of public opinion. Our goal is to train students as people of intellect, not for vocation. Young children have the intellectual capacity to learn science. Contrary to earlier ideas about child development, recent research shows that children's thinking is surprisingly sophisticated. Children can, for example, demonstrate causal reasoning and distinguish reliable from unreliable sources of knowledge. Recent advances in cognitive science suggest that children think and learn in fairly similar ways to adults, but differ from them only in that they have less experience to draw upon when making sense of what they encounter.

Why is science important? - I

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Why is science important? - II

Given the scientific consensus on the cause of global warming and climate change, teachers should teach the scientifically accepted perspective on global warming and climate change—not debate it. Debate and controversy lie in social, economic and political approaches to mitigation and adaptation to global warming and climate change. Teachers can engage students in discussing these different approaches and solutions to climate change and making policy decisions about energy use.

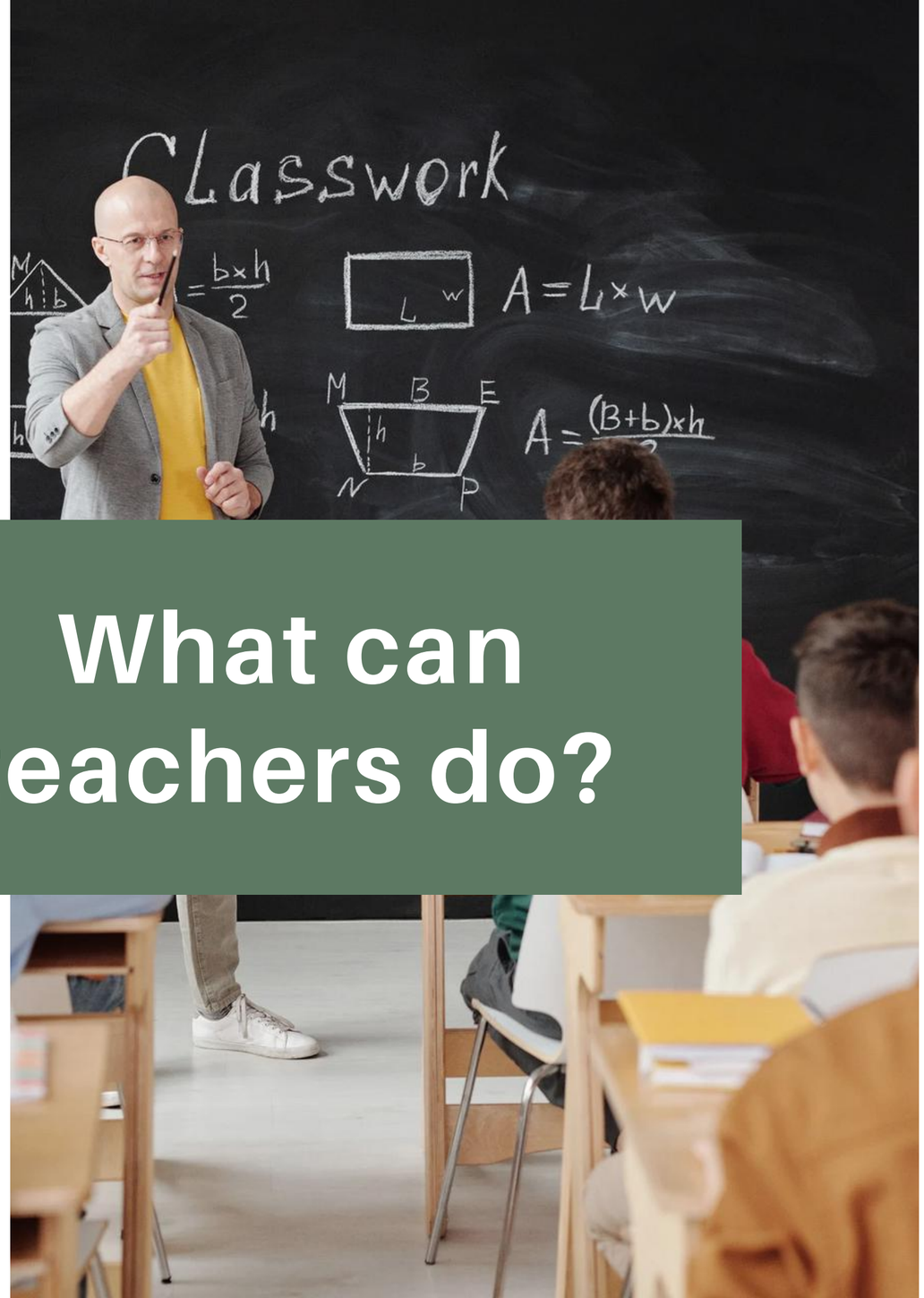
Teaching and learning about global warming and climate change is not simple through science. Students cannot monitor climate change directly due to time and space issues. Thus, in order to learn about climate change, it is necessary for them to interpret, analyze, explain, and evaluate climate data, model-based data projections, and conceptual models. Students need opportunities to think systematically about the Earth's energy budget, the climate system, and climate change. They need opportunities to research and consider data on energy use and carbon emissions. It is also important that students are given the opportunity to make informed decisions about their own actions and behaviors, as well as those of the societies in which they live.

Why is science important? - III

Education about climate change in schools is sporadic and limited, despite the interest of students and the increasing urgency of the issue as temperatures rise and weather conditions become more severe. Whether or not you have formally become involved in teaching about climate change, you will gain a high enough level of expertise to help others understand the topic at the level necessary for an informed citizenry.

Learning is the first step towards stopping global warming. Research has shown that when students complete courses in climate science, their attitudes toward climate issues change permanently. There are several roles of science that are considered to have a huge impact in schools, such as:

1. Fulfilling the growing need for knowledge. Our students need to hear and see the reasons why our planet is increasingly affected by global warming.
2. Focusing on developing powerful scientific ideas.
3. Collect information, organize it and test their ideas.
4. Developing their ability to ask questions about the current problems of our planet. Science can also create curiosity that helps students understand and formulate questions about the information they have gathered.
5. Increasing the ability to understand, use and interpret scientific explanations of the natural world.
6. Generation and evaluation of scientific evidence and explanations.



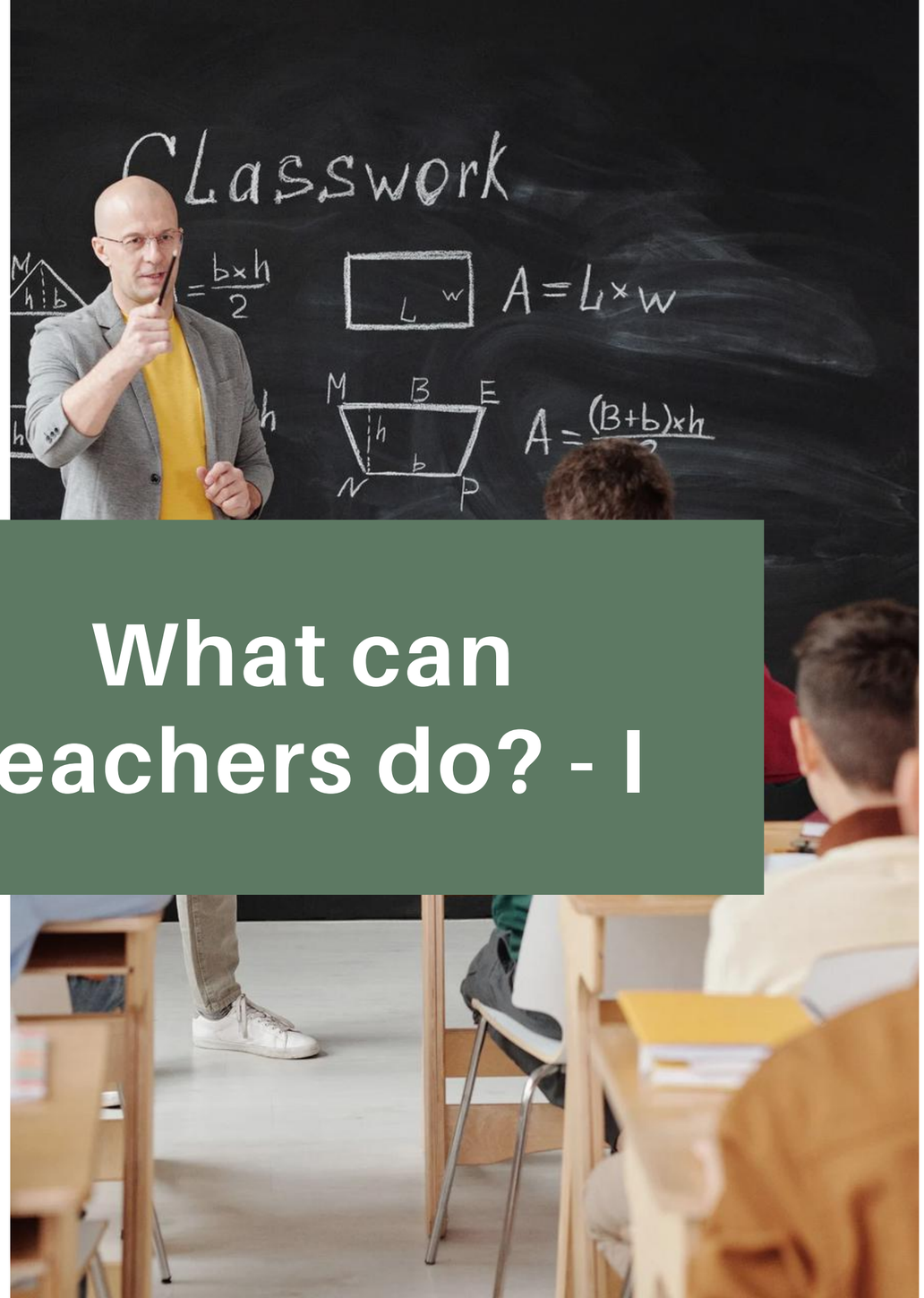
What can teachers do?

As teachers, it is our duty to make students aware of pressing issues like global warming. Our students will get the facts. We hope that students will not only understand what global warming is, but also want to help. We hope to motivate our students to make immediate changes in their homes and communities, simply starting with educating and encouraging their families.

Climate change is an interdisciplinary scientific topic. Aspects of the topic can be taught in different science classes without losing the general ideas about systems thinking, managing uncertainty, and building arguments from multiple lines of data.

Students' climate anxiety and despair can be alleviated by learning about collective and individual climate solutions. By making climate change feel personal, urgent, and close to home, students' values and identities change—and they take informed action. This is what happens when teachers spend more class time on climate solutions than on decontextualized science. Spend 3/4 of the instructions researching the solution.

Providing students with climate solutions pedagogy and resources not only meets their social-emotional needs, but can also improve their academic achievement and preparation for life and work. Learning about climate science involves engaging in interdisciplinary, field and project-based, experiential, collaborative learning. This approach results in greater student engagement in core subject area content and the development of higher-order cognitive skills, such as critical thinking and problem solving. Solution-oriented action—as in the Multisolving Framework—involves youth in socially just care for their local community.

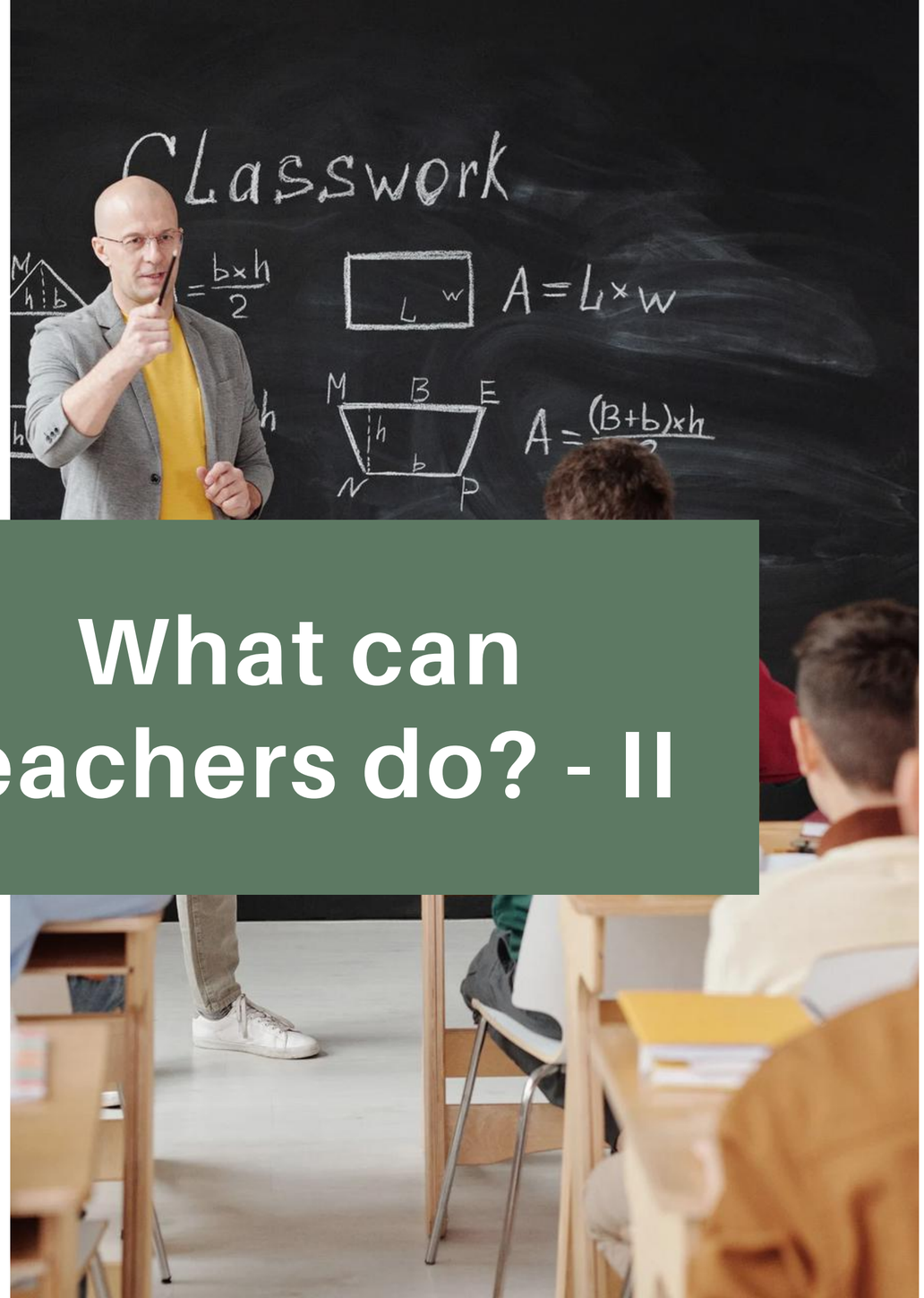


What can teachers do? - I

- Effective practices in climate science education focus on solutions. Teaching should: be personally relevant and engaging; build students' problem-solving and engineering design skills in the classroom and community; help students in building their own ideas; involve students with scientists in collecting; analyze and apply data.

- Teachers could also use curriculum focused on climate solutions, assessment tools, and other learning resources. Climate solution stories, digital games, carbon footprint calculators, and virtual reality simulators are on the rise, often come with teacher guides, and can be powerful incentives for engaging students in climate science learning and solutions.

- Consider: Cool School Challenge, Climate Game Changer, Learning in Places, and this team-focused EcoChallenge carbon footprint reduction tool from the NW Earth Institute. Provide students with field learning experiences with climate solutions experts in your community, including Indigenous elders and scientists, local green technology business people, farmers, foresters, water and soil scientists, food sovereignty experts, etc.

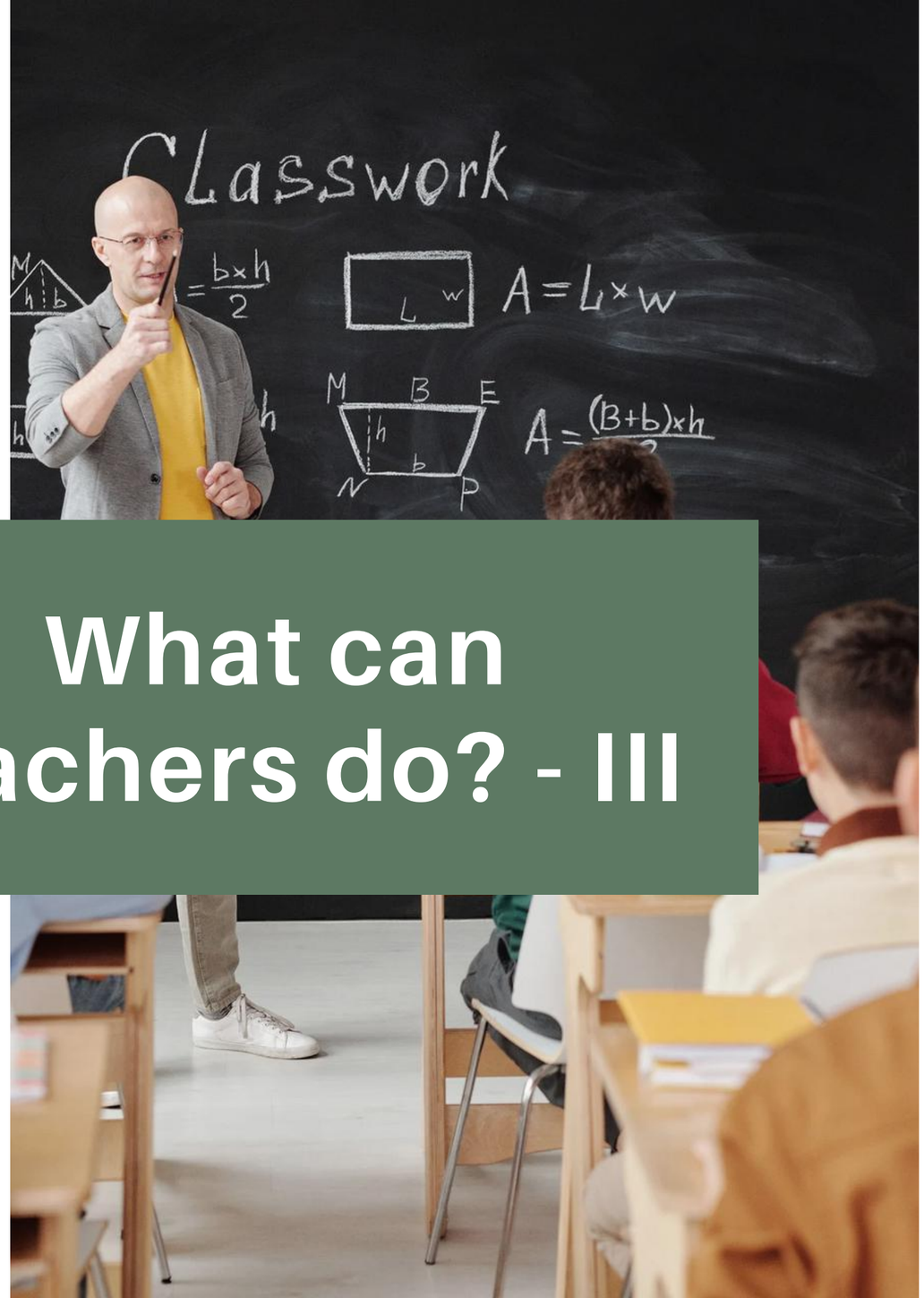


What can teachers do? - II

Furthermore, here are topics that are likely to be discussed, debated and observed during science class:

The climate is warming: Thermometer and satellite measurements show unequivocally that the climate is warming. Each of the last four decades has been much warmer than the last, and each has set a new and significant record for highest global temperature. Confirmation of global warming also comes from melting glaciers, rising sea levels, retreating Arctic sea ice, reduced snow cover and other changes. Long records of past climate show that warming over the past 60 years is unprecedented in the long-term context: https://youtu.be/YQMtb1Pd07E

Global warming is already affecting the weather: Climate change is increasing the frequency and intensity of some types of extreme weather. In recent years, new techniques have been developed to determine the impact of human-caused global warming on certain types of extreme weather and even on specific events. What were once very rare events are now becoming more common. Human-induced warming is causing more rain to fall during heavy downpours. Heavy rain contributes to flooding that damages buildings and roads, erodes soil and washes pollutants into waterways. Students can study the effect of flooding on their area, measure the damage, and come up with ideas that could help prevent the loss, such as planting trees, installing "check valves" in sewer traps to prevent floodwaters from building up, or building the interior of a barrier. to stop low level flood water from entering basements.



What can teachers do? - III

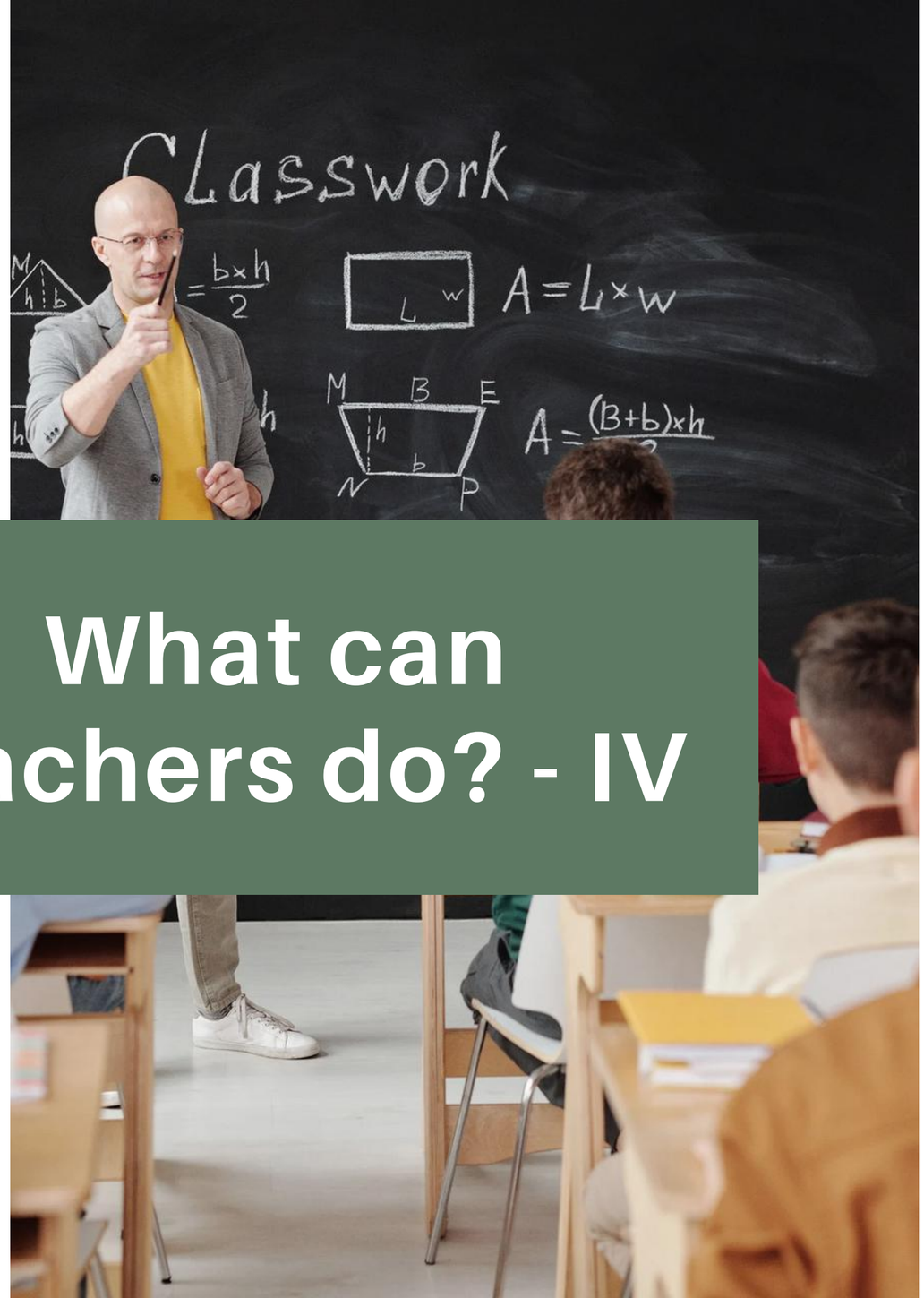
- Sea levels are rising: After about 2,000 years of little change, average global sea levels have risen by about 20 centimeters (7-8 inches) since 1900, with about half of that occurring since 1993. The seas on Earth are growing at an accelerated rate, a direct consequence of human-caused climate change.

- Students will find answers to some questions: What are the causes of sea level rise? /What controls sea level? /What is the threat of sea level rise?/What can we do to help?

- There are other major questions that students are likely to be presented with during their science class regarding global warming, such as:

- Depletion of water resources (Warming over the past several decades has led to many changes in the water cycle, including changes in precipitation patterns and intensity, greater frequency and extent of droughts, widespread melting of snow and ice, increases in atmospheric water vapor, increases in evaporation, increases in water temperatures , shrinking ice in lakes and rivers, and changes in soil moisture and runoff.The impacts of these changes include too much water in some places and times and too little in others.

- Food production (Climate change is increasingly hampering efforts to meet the world's food supply and nutritional needs. The effects of climate change – including weather extremes such as droughts, floods and marine heat waves – are stressing agriculture, aquaculture, forestry and fisheries.

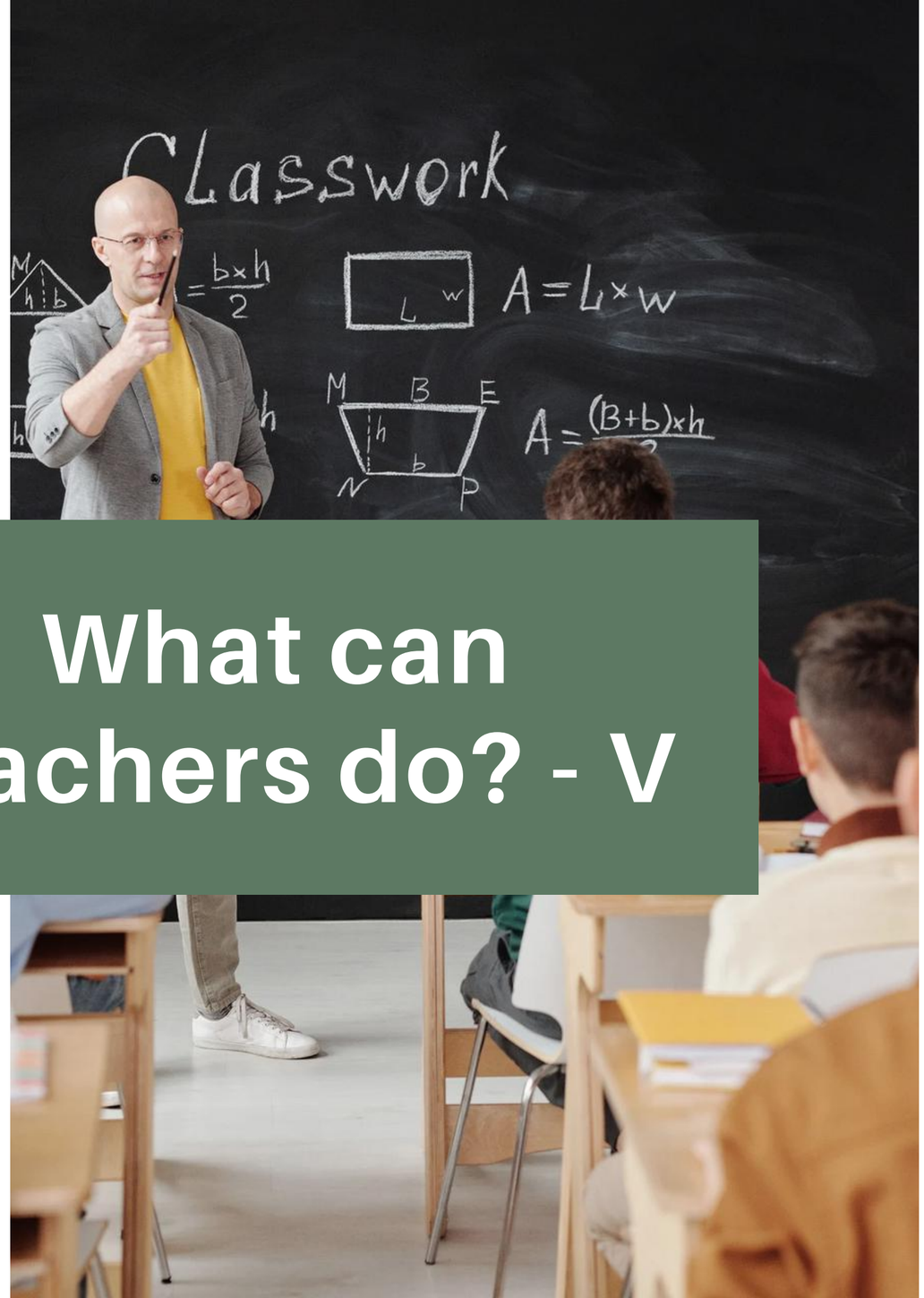


What can teachers do? - IV

- Human health (Heat waves, droughts, wildfires, heavy downpours, floods and other extreme weather events are predicted to become more frequent and intense, with serious consequences for human health and well-being. The effects of extreme weather events include illness or death from heat stress, injuries, drowning, air and water pollution and mental health effects Higher temperatures, heavier downpours and floods can lead to contamination of drinking water and food.

- An increased incidence of cardio-respiratory diseases caused by higher concentrations of ground-level ozone (smog) is predicted. Warming of 2°C would increase the risk of conflict by 13%, due to reduced food and water security and disruption of lives and livelihoods. This instability can lead to civil unrest in some regions, often linked to increased violence against women, girls and other vulnerable groups. Climate solutions are health solutions. Many climate solutions will provide immediate, often localized, health and equity benefits.)

- Animal and plant species (polar species, including polar bears, ice-dependent seals and emperor penguins) are particularly vulnerable to the effects of climate change as their unique ice habitats shrink due to warming. Mountain species are at risk as warming changes the climate uphill, and those living on mountaintops are running out of suitable climatic space. Corals and other species that depend on them are also highly vulnerable to the combined effects of warming ocean water, ocean acidification and other human-caused stresses. Species at risk of extinction are increasing as global temperatures rise. For example , at 1.5°C, about 10% of species could be critically endangered, increasing to as much as 40% at 3°C, and almost half at 5°C.Temperatures in this range could be reached this century if emissions are not reduced.



What can teachers do? - V

- Ecosystems (When considering the impacts of global warming on species, it is essential to look at how entire ecosystems are affected by how species and climate change interact with other human-induced stresses. It is clear that climate change will have, and is already having, profound effects on the natural world. At every continent, plant and animal populations change in ways that reverberate throughout ecosystems and affect humanity in a variety of ways. Healthy ecosystems provide humanity with many valuable resources and services, ranging from food (such as fish) to coastal protection (sea ice represents barrier that limits coastal erosion) Climate change can seriously degrade or even completely eliminate certain types of arctic, alpine and coastal ecosystems.

Activity: Greenhouse effect in a jar

Students will see greenhouse effects and relate this understanding to what is happening in our atmosphere. This activity allows students to use simple experimental techniques such as observing and recording data and drawing conclusions from the results. For this experiment, students will work in groups of four. The materials you will need are as follows:

2 small thermometers
1 jar or other transparent container
1 hour or an hour
Scientific journals (for record keeping)
A solar lamp or access to a sunny area

First, each group should place their thermometers a few inches apart under a sun lamp or in direct sunlight. Wait about three minutes for the thermometers to give accurate readings, then have students record the time and temperature readings on both thermometers. Next, each group should place their jar on top of one of their thermometers, making sure the jar does not cast a shadow on the uncovered thermometer. If the thermometers are too big, you can lean them against the inside of the jar. Every minute, for ten minutes, students should record the readings of both thermometers.

Activity: Greenhouse effect in a jar

Students should notice that the air above the exposed thermometer is constantly changing, and as it warms, it is replaced by cooler air. Since the air in the jar cannot circulate, that air stays in the sunlight and gets warmer. Similar heat retention occurs in the Earth's atmosphere. Sunlight passes through the atmosphere and heats the Earth's surface. The heat radiating from the surface is trapped by greenhouse gases. Without an atmosphere, Earth's average temperature would be about -13°F. This warming due to heat-trapping gases is called the "greenhouse effect". But the jar and the atmosphere allow light in, but then trap that energy when it's converted to heat. However, they work differently because the jar is trapped in the heated air, while the greenhouse gases absorb the radiant heat.

At the end of the activity, students should reflect on this in their journals. Students should describe what they learned from the experiment. Students can also graph their data and present their posters to the class.

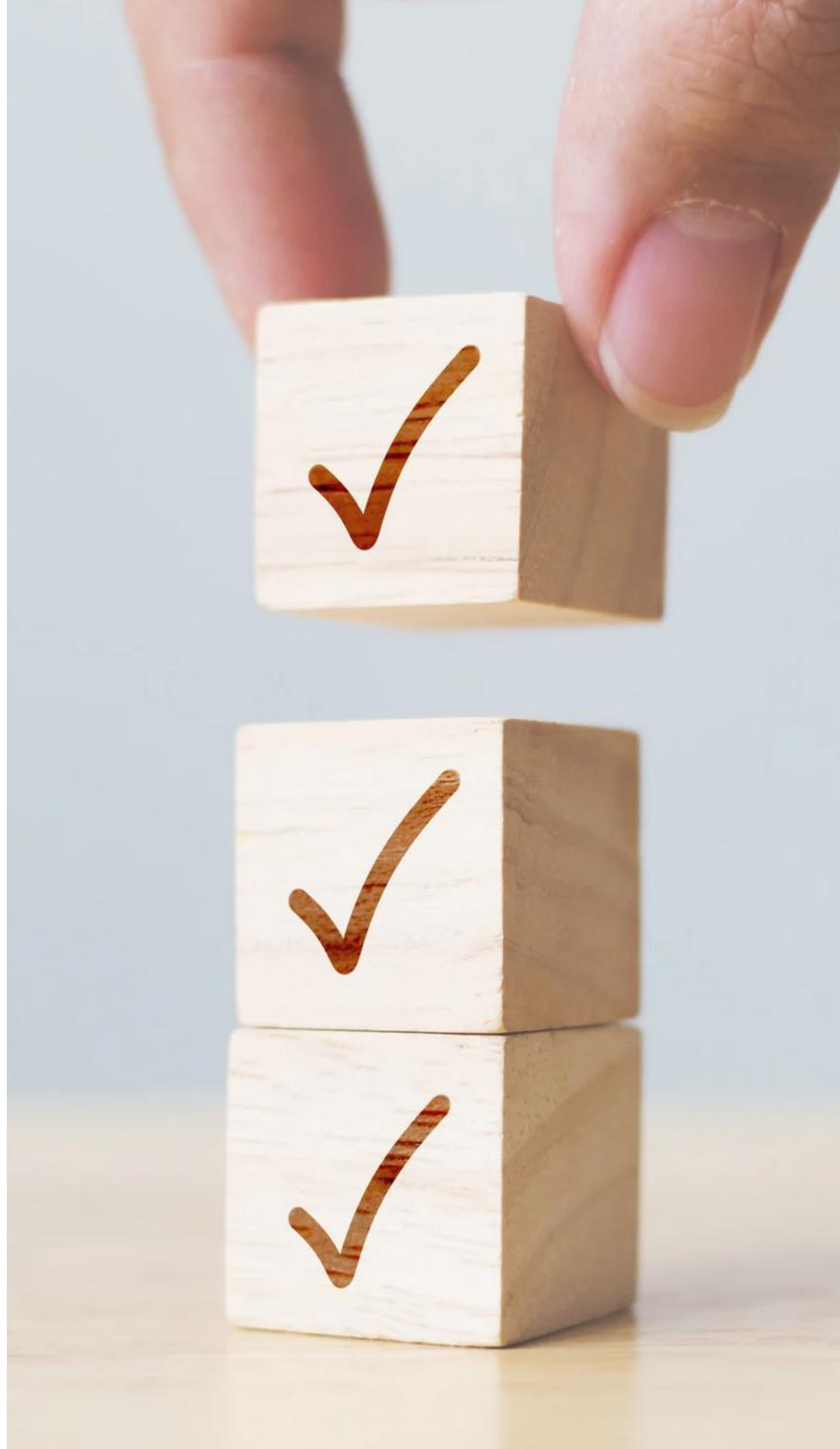
There are also two more experiments that can be done next. For the first possible experiment, use two jars, paint the bottom of one jar black and the other white. Students will see that white reflects more, so the temperature will increase less, while black absorbs more. For the second experiment, use two jars to simulate global warming. One jar will be filled with air and the other will be filled with carbon dioxide.

Concluding remarks

It has been proven that many students change their daily behavior after studying climate change. The researchers believe that if enough people went through this process, the overall reductions would rival larger-scale efforts.

Keep in mind that when discussing climate change in the classroom, we need to remind students that scientific arguments are supported by multiple lines of observed and modeled data, not political opinions or untested assumptions. We will enable students to engage with social controversy by evaluating media and political arguments in light of the evidence provided. Students can investigate whether speakers use scientific evidence to support their claims.

It is important that students understand simple things they can do at home. There are several great ways to involve students and their families. So many things we do in our daily lives (driving, cooking, heating homes and working on computers) result in greenhouse gas emissions. It is impossible to eliminate our personal contributions, but we can reduce our contributions.



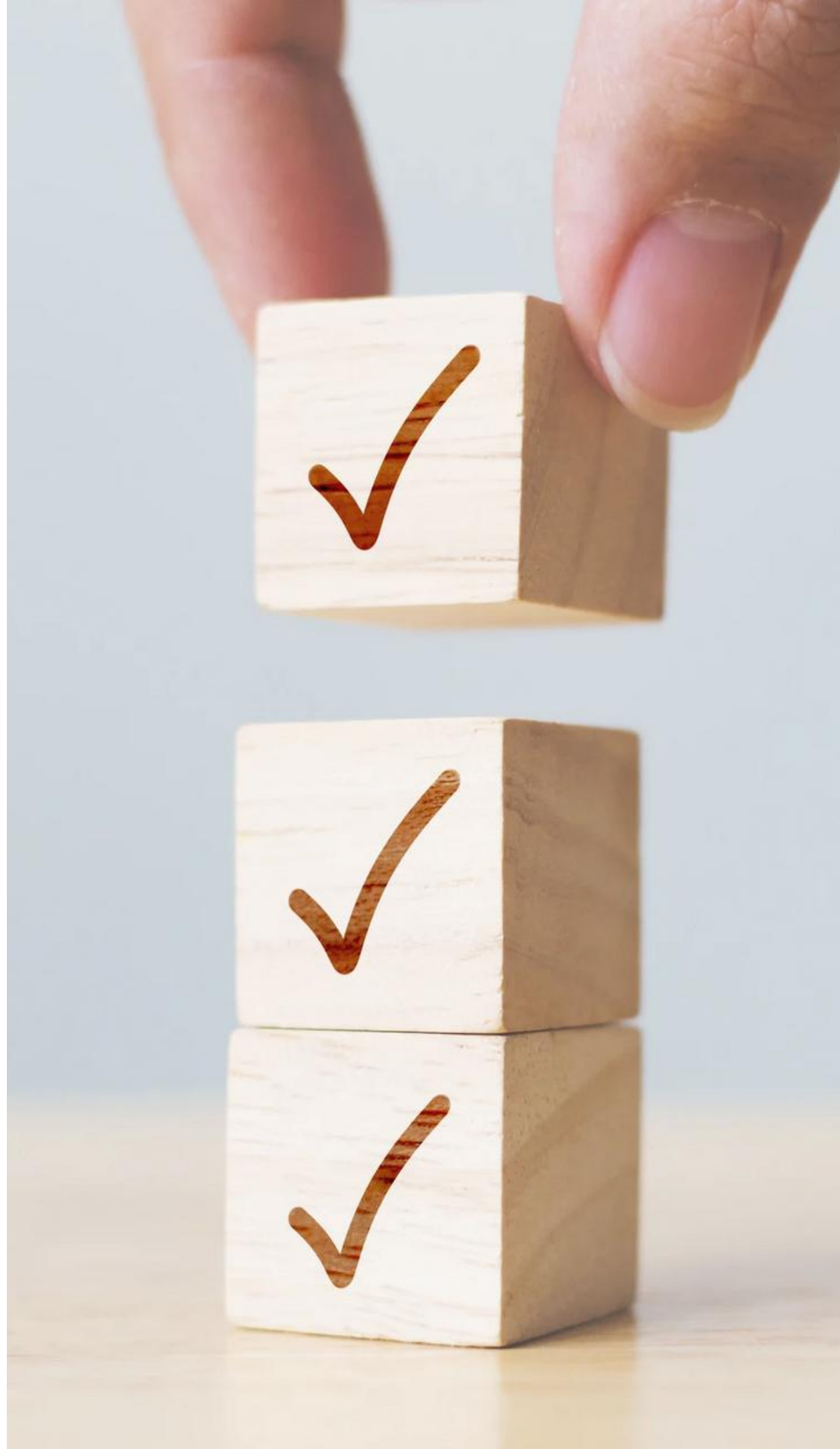
Concluding considerations - I

We can replace conventional incandescent bulbs with super-efficient compact fluorescent lights (CFL). They use 66% less energy and reduce household emissions by up to 10%. We can buy energy-efficient appliances to reduce household emissions by up to 50%. It is also important to handle and maintain appliances properly (only put the dishwasher and washing machine on full load and use a clothesline to dry clothes instead of the dryer). We can heat and cool the house efficiently. By turning the heat down a few degrees in the winter and setting the air conditioner up a few degrees in the summer, you can save energy. It is also important to insulate your house so that energy does not "leak". We can save hot water by showering instead of bathing and washing clothes in cold water instead of hot. Most importantly, reduce idle energy waste by turning off devices that are not in use.

"Reduce, Reuse and Recycle." It is important to recycle things like paper, glass, steel, aluminum and plastic at home, at school, at work and everywhere. Although energy is required to collect, transport, sort, clean and reprocess these materials, recycling requires much less energy than sending recycled materials to landfills and creating new paper, bottles and cans from raw materials. One way to save money is to bring a reusable bag when shopping for groceries and other items. Another way to save money is to carry your own refillable water or other beverage bottle instead of buying disposable plastic bottles.

We must continue to teach and learn about the state of the environment and what is being done about it. We need to share our knowledge with others. Tell your family and friends about climate change and what they can do to help solve the problem. We need to inform and encourage others to take action. We can raise awareness in our neighborhoods and schools and find ways to implement programs in our community.

All in all, if we preserve nature, we will find refuge in it!



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2. Chapter

Climate change and technology

Introduction

Traditionally, STEM subjects are considered by some students to be more distant from everyday life than humanities subjects. However, as issues related to climate change grow, younger generations are quickly becoming aware of the importance of STEM subjects in everyday life.

The climate crisis has brought science, technology, engineering and maths (STEM) to the fore among younger generations - with millions of young people marching around the world, calling on the world to listen to Greta Thunberg and "unite behind science". As a result, we see young people becoming increasingly aware of climate-related issues.

Since human activities are one of the main causes of the climate crisis, it is clear that humans must be the solution. Raising people's awareness of the climate crisis brings positive changes in global indicators of climate change; educational institutions also have this great responsibility. Raising students' awareness of the climate crisis - especially at a younger age - contributes to solving the problem.

Because of the climate crisis, far more people are engaged in science and technology than they are naturally inclined to do. Science and technology will be at the heart of any solution to the adverse effects of climate change, so interest in it is a very positive step and needs to be further supported and encouraged by schools and educators, and there are various ways to make this happen.

Technology in STEM education:

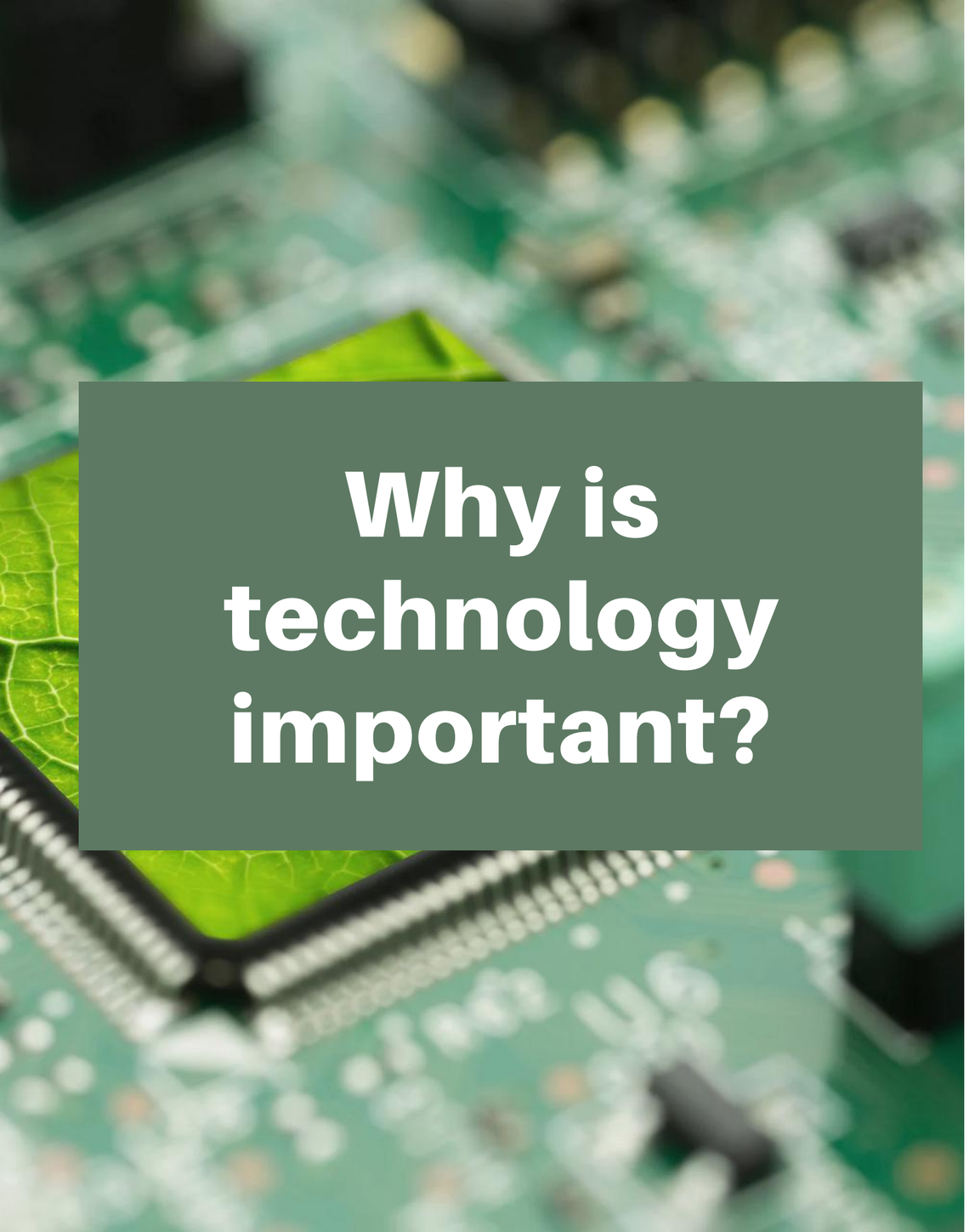
it can be seen as a product of engineering given its historical connection with vocational education.
can be defined as educational or instructional technology used to enhance teaching and learning.
can be defined as tools used by practitioners of science, mathematics and engineering.

Teaching technology and climate change

Climate change is one of the most challenging problems facing humanity in the 21st century. The chaotic and intricate aspects of climate change can only be solved through the inclusive participation of all members of our communities with technologically sound and educated solutions. Educating our youth about the urgency of climate change is imperative and is the first step in taking action on climate change. In order to achieve the goal of a sustainable future, it is necessary to equip students with the knowledge and skills to deeply understand the climate crisis and its potential impacts on the environment.

The use of interactive tools, such as simulations, digital resources, and web-based activities, has the potential to engage students in meaningful dialogue, encourage creative problem-solving, and provide an essential foundation for making informed decisions about their future.

By focusing on the use of interactive tools that are tailored to the needs of students, we can ensure that climate change education is effective and engaging for all students. International scientific and climate bodies such as NASA, IPCC, NCAR and UCAR provide certain educational interactive tools that have enormous potential in motivating student interest and engagement by displaying real-time data on current weather, climate, emissions and impacts and future projections of these parameters.



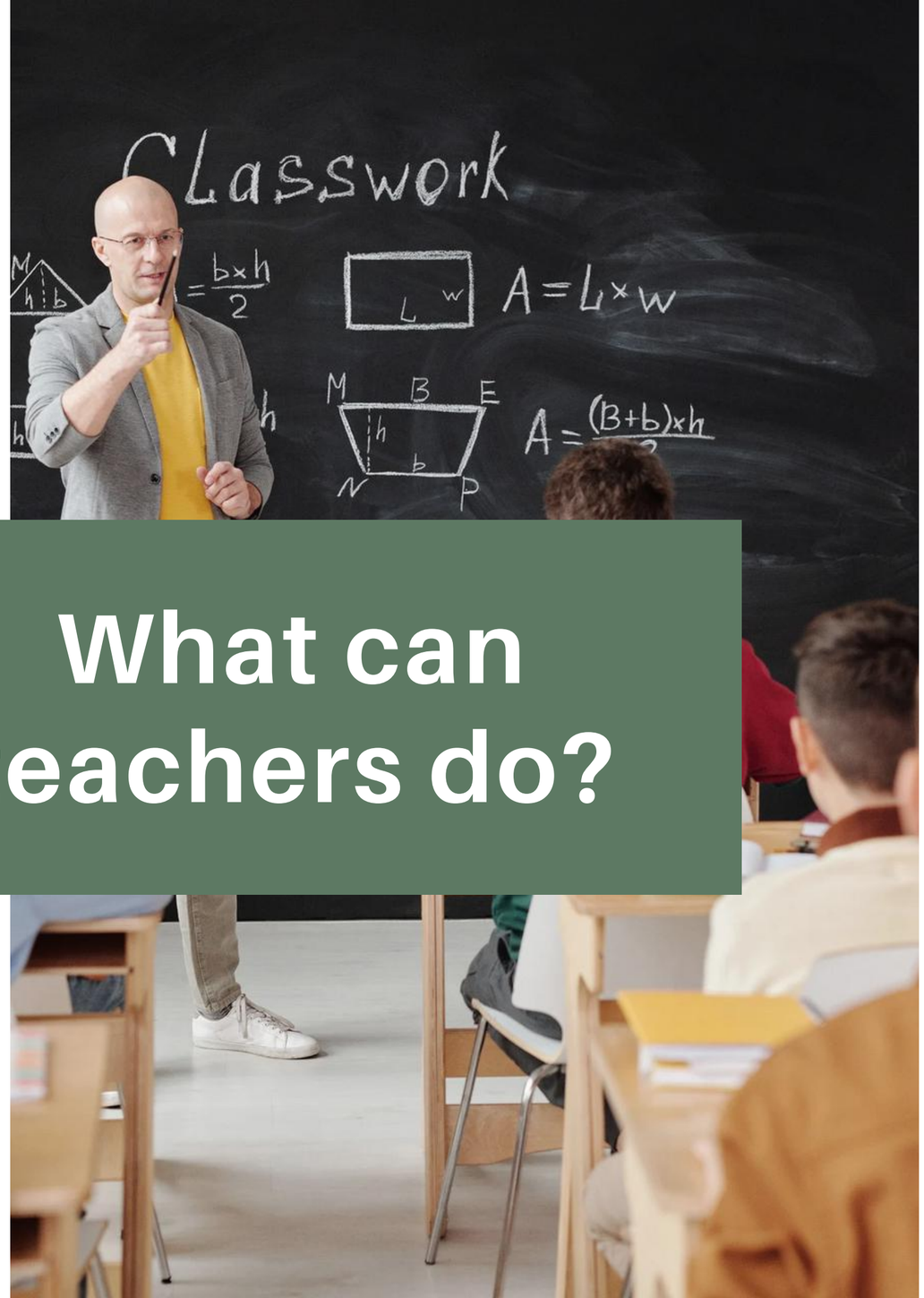
Why is technology important?

Technology has historically played an interesting role in climate change. The first major impact occurred in the 1880s during the Second Industrial Revolution – also known as the Technological Revolution – when coal was first used to generate electricity for homes and factories.

Technology has brought many changes to society and affected the environment in the past. All this is due to lack of knowledge and research. Today, scientists have found a wide range of alternative energy sources. They already help reduce the concentration of dangerous substances in the atmosphere. Such resources belong to "renewable energy", examples of which are solar energy, wind energy, hydroelectric power, geothermal energy and biomass. Society must follow certain rules listed below to solve the problem: reduce dependence on cars and use public transport more; use of domestic energy efficiency; transition to carbon-free energy supplies; increase the amount of renewable energy by developing carbon storage and capture techniques.

Achieving a satisfactory result requires high costs and a long time. Nevertheless, the chances of technologies to combat climate change are great. Society could become less dependent on carbon in the short term.

According to Volti (2010) “technology is not only the source of environmental problems; it can also be part of the solution”. The latest use of hybrid cars, renewable energy use, and the use of wind energy are all forms of technological advancement that could help with the outcome of global warming. Although technology can help stop global warming, it cannot be the only factor in it.



What can teachers do?

Many believe that including subjects related to climate change in the school curriculum will help young people cope more easily with the reality of global warming, both practically and psychologically.

Teachers have the power to act now, as climate change reportedly causes anxiety among young people, schools should use STEM education to ease those fears. Science teachers can engage students in climate-related science lessons. By promoting further awareness of key climate issues, educators can ensure that the next generation is equipped with the information they need to tackle the problem – and inspire young people to start the debate about how to build solutions for them. It is important that we always frame these discussions in a way that emphasizes how we can all play a major role in preventing the escalation of climate catastrophe. In this way, students can feel more in control of their problems and their future.

Teachers can use technologies to promote students' awareness of climate change. As an example, the initiative "I'm learning to code and love nature" can be launched. Students will receive environmental coding training. In this way, they will improve their coding skills and at the same time introduce them to environmental topics. Students can design climate solutions using the software and robotics tools they have developed.

With the wide range of technologies available to science and STEM teachers, it is important to empower teachers to be critical consumers of technology. Technologies in the classroom should be carefully selected based on their alignment with desired learning outcomes, and rather than focusing on which technologies to choose, teachers should focus on how they are used. Even technologies that are widely accepted as central to STEM fields (such as 3D printers) can be used in an inauthentic way. Technology for technology's sake often does not lead to students' conceptual learning.

Examples of activities

New technologies make it easier to identify sources of emissions, stop further damage with greater energy efficiency and lower carbon alternatives to fossil fuels, and even remove excess greenhouse gases from the atmosphere. But when we talk about technologies (ICT) that can be used to teach students, we want to emphasize some useful tools.

Climate time machine

Using NASA's Earth observation satellites, students can track how some of our most influential climate indicators have changed over the years. Using this interactive 3D visualization, they observe progress in sea level rise, carbon dioxide emissions and global temperature fluctuations.

Earth project application

The Earth Project app allows you to track the positive impact you have on the climate through actions. The app teaches and motivates students to reduce their carbon and plastic waste. The Earth Project app was created as part of TAG's Climate Action Project, which was launched in schools in 142 countries around the world. The app allows you to take action and track progress.

Climate Kids by NASA

From greenhouse gases to water and energy use, this interactive, kid-friendly website has tons of great games and educational resources about the climate change process, energy science, and how students can get involved.

Examples of activities - I

European atlas of the seas

The European Sea Atlas is an ideal tool for schools, researchers and professionals or anyone who wants to know more about Europe's seas and its coastal areas!

The European Sea Atlas is an ideal tool for schools, researchers and experts or anyone who wants to know more about Europe's seas and its coastal areas. It is a digital interactive learning tool that provides information about Europe's marine environment in the 24 official languages of the European Union. It is managed by the secretariat of the European Marine Observation and Data Network (EMODnet). Users can view ready-to-use pre-defined maps covering topics such as environment, tourism, security, energy, transport, waste, seabed, fishing, aquaculture and more. Users can also benefit from an enriched catalog with more than 250 map layers, covering a wide range of topics, to research, compare and create their own maps. These maps can be printed, shared and embedded in articles or presentations.

Climate change games

They can serve as effective tools for education and engagement. Recently, there has been a dramatic increase in the development of such games, many of which have innovative designs that blur traditional boundaries (for example, those involving social media, alternate reality games, or those involving direct real-world action).

Sea Level Rise IQuest

The lecture schedule is available here.

Examples of activities - II

Climate footprint

Launched in 2020, Climate Trace is an innovative, easy-to-use interactive resource that uses scientific observational data, AI and ML technologies, and remote sensing-based tools and imagery to track the amount of anthropogenic greenhouse gas (GHG) emissions around the world. Educators teaching climate courses can use this tool to teach students about the greenhouse effect and the amount of greenhouse gas emissions emitted by different sectors. This interactive tool can serve as a supplement in creating awareness among young students and researchers about the greenhouse effect and emissions and their role in global warming.

Earth.nullschool.net

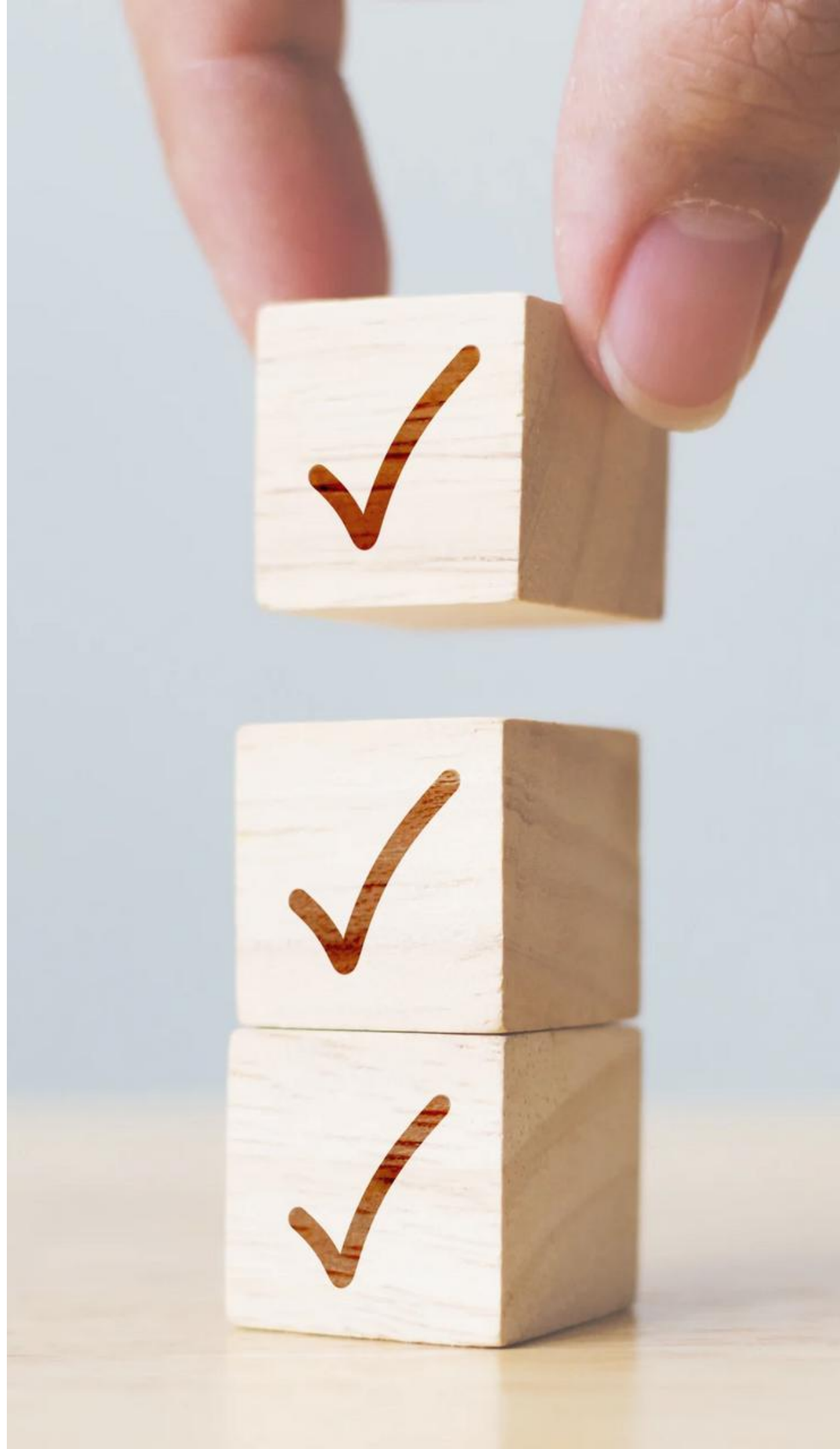
Earth.nullschool.net is part of the Climate Literacy and Energy Awareness Network (CLEAN) collection of educational resources. The interactive website presents a fascinating view of planet Earth with near-real-time visualization maps and historical patterns of the air, oceans, chemicals, particles and space. The tool allows users to see current weather, ocean and pollution conditions on an interactive, animated map, as predicted by a supercomputer. Teachers can use the platform in their classroom activities to visualize weather elements, atmospheric composition of gases and particles, giving their students a unique and engaging learning experience.

Choose Our Future (based on the game)

The University's Corporation for Atmospheric Research Center for Science Education is another fantastic climate research tool for young learners. Choose Our Future allows students to see the variation in their greenhouse gas footprint based on decisions they make such as carpooling to school instead of using a car or going on an international vacation instead of a local trip. These small decisions of the players affect the numerical values of the greenhouse gases they emit. Teachers can get students to understand the effect of their daily habits on the climate through this choice game. The average global temperature changes depending on the student's selection.

Concluding remarks

The potential of technology to help us mitigate and adapt to climate change has yet to be fully exploited. The UN calls for greater and faster action for the development, application and transfer of climate technologies to developing countries. Analyzing the impact of technology, we can say that it balances between the last two. Roughly speaking, technology can solve the problems they created. Improving the environment, especially global warming, requires resorting to many changes. Society must show enough will and effort to go through the transition period from carbon. The transition to alternative energy sources such as sun, water, wind must be a priority.



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Chapter 3

Climate change and engineering

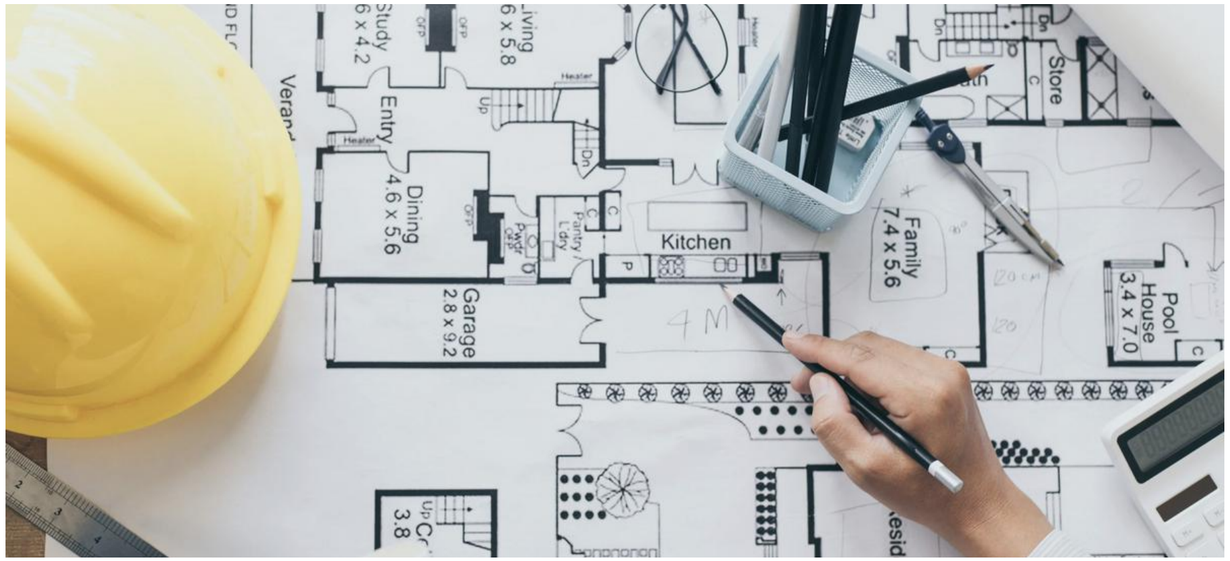
Introduction

Since the second half of the last century, the topic - Engineering response to climate change, has been persistently discussed in international forums, where they try to think about the role that engineers can play in mitigating and helping society to adapt. to climate change. We are tempted to recognize that these concerns, today, probably and unfortunately, do not deserve special attention due to the difficult times we are going through and the corresponding impact of multiple factors that are dangerously converging -¬ the pandemic, the war in Europe, energy shortages and the galloping rise in oil prices - creating explosive cocktail. We have witnessed unspeakable tragedies with no end in sight. We also recognize that humanity has been able to overcome enormous difficulties and survive various tragedies by exploiting to this end all the resources at its disposal and the knowledge that has been accumulated or is yet to be discovered. Many scientists and engineers, legislators and politicians around the world are involved in the search for answers.

Many of the answers and solutions the world is looking for and needs today are engineering. In terms of infrastructure, buildings, digital transition, there are a number of "new paths" that engineering can follow. Therefore, our near future needs not only the fulfillment of goals, but also (and many) engineers.

After the first revolution (the appearance of the steam engine), the second (electricity, production line) and the third (electronics, robotics), the fourth industrial revolution is coming, which will combine numerous factors, such as the Internet of Things (IoT) or Big Data, which is initiated, and will continue to stimulate, the transformation of the economy. The use of the Cloud, the development of a greater capacity to store information on a large scale, solutions capable of handling a large amount of Big Data digital data (due to its size in volume, variety and speed) expand the horizons of benefits. The so-called 4th industrial revolution, emerging with a new paradigm, Industry 4.0, supported by the program of the same name, designed for competitiveness and innovation, will combine numerous factors such as IoT or Big Data. It will be a transformation of the economy that will see the digitization of industry, infrastructure, buildings and society, enabling the interactivity of physical, digital and even biological spaces, intelligently contributing to mitigating the effects of climate change.

Engineering education and climate change



Education is a decisive factor in the increasingly urgent fight against climate change at the global level. Knowledge related to this phenomenon helps young people to understand and cope with the consequences of global warming, motivates them to change their behavior, cooperating in adapting to what is already urgent in the global framework. Benjamin Franklin once said, "An investment in knowledge always pays the best." In the ecological sense, more precisely in everything related to climate change, this is also confirmed by UNESCO. For this international body, education - especially aimed at children and young people - is an essential factor in stopping climate change. More specifically, UNESCO indicates that "education promotes a change in attitudes and behavior and helps in adapting to trends related to climate change". Therefore, the importance of environmental literacy is increasingly important in our society.

Engineering teaching and climate change - I

In recent years, various initiatives have been implemented to try to stop climate change. It is worth noting the 17 Sustainable Development Goals (SDGs) promoted by the United Nations (UN) since 2012. Among them is number 13, which refers to action against global climate change. The success of this type of initiative largely depends on the environmental literacy of the population, often alien to these major political agreements, and on the development of a culture of concern for the climate. But what exactly do we mean by environmental literacy? Educating means making citizens, especially children, aware of the causes and consequences of climate change.

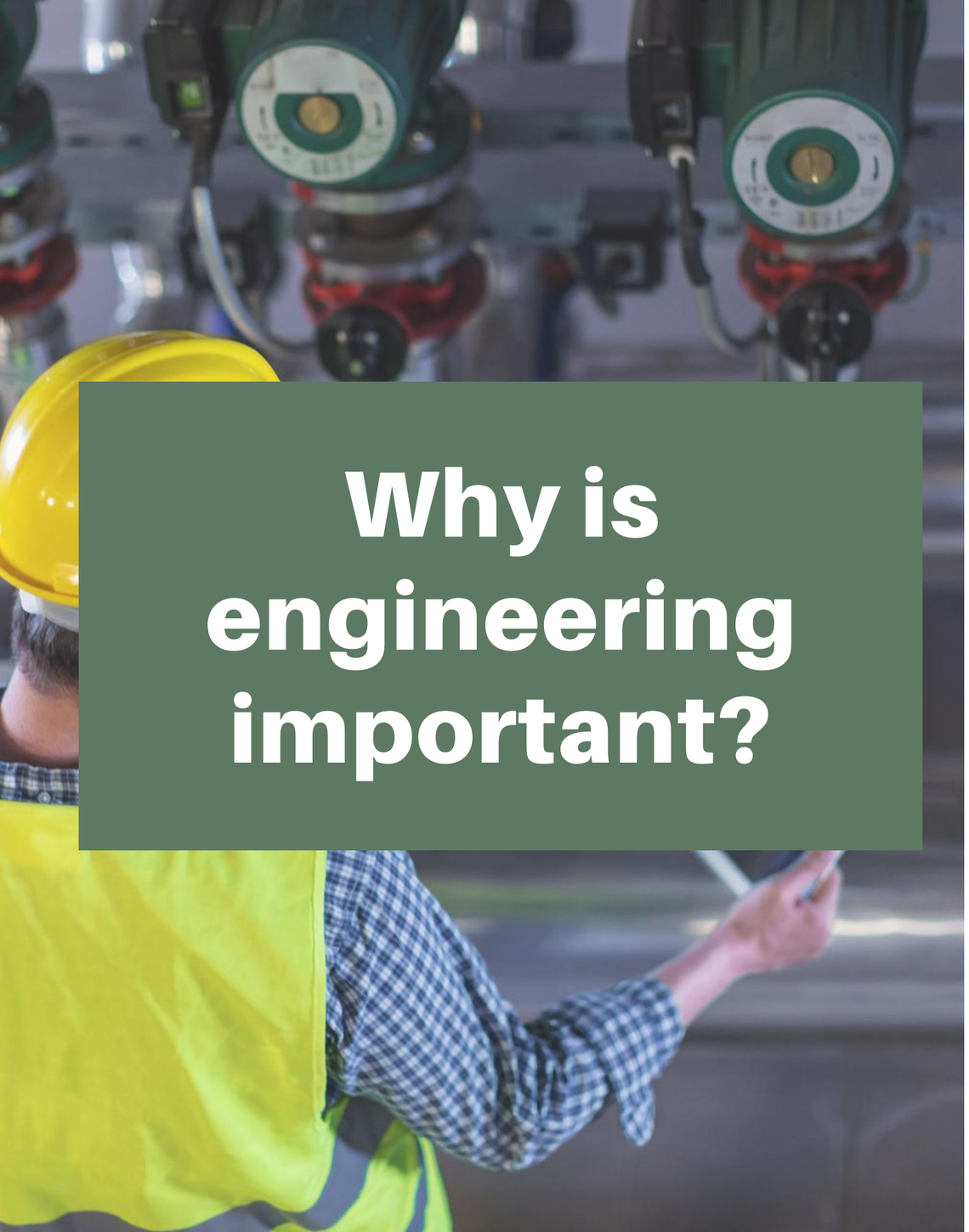
In fact, the UN, as part of its educational commitment to climate change, points out that "it is equally important to make progress in areas such as reducing greenhouse gas emissions and creating effective government policies, such as providing education and training to raise awareness as widely as possible." Along the way, experts emphasize the importance of starting to deal with terms that until now seemed reserved for scientists. We talk for example about global warming, greenhouse effect, renewable energies, carbon footprint, deforestation, recycling, green jobs, green taxes, water footprint, sustainable food.

In addition to knowing and using vocabulary, an increasing number of people are focusing on the importance of educating children about environmental protection issues and developing a culture of caring for the climate. For example, a recent Stanford University report analyzed how this discipline benefits students from kindergarten through high school, concluding that 83% of students improved their environmental behavior.

Engineering teaching and climate change - II

How to implement environmental protection training in schools? Apart from inclusion as a compulsory subject (an option chosen so far only by Italy in Europe), there are several activities on climate change that can be carried out in schools. For example: carrying out activities in nature related to environmental care, cleaning work, visiting farms and nurseries to learn first-hand how to care for animals and plants, organizing courses and workshops on recycling, etc. There are also numerous technological resources, such as the Educaclima platform, which offers teachers free educational resources related to the environment, climate change, responsible consumption, energy and mobility, etc., so that they can put them into practice in the classroom with children. Training in the disciplines - Science, Technology, Engineering and Mathematics (STEAM) will enable young people to better understand the physical changes in their environment and will give them the tools to fight climate change. The training system in this sense will also enable the formation of qualified experts for green jobs that will emerge from an equally green economy. Support the teaching of environmental education in schools It is necessary, either as an independent subject or as a transversal subject within the school curriculum, to cultivate values and knowledge about the environment among young people so that they can live a more sustainable life. To stimulate their curiosity about the natural world and their concern for the health of the planet, we need to encourage teacher training programs in this regard.

Teaching engineering in the education system can help answer most of the problems that climate change brings us. It helps promote true environmental education around the world. It improves the skills of information assimilation, risk calculation and preparation for climate crises. Strengthening education in science, technology, engineering and mathematics (STEM) enables the formation of specialists qualified for the green economy. It also enables the construction of schools that convey ecological principles, i.e. that use energy efficiently and promote a relationship with the environment.

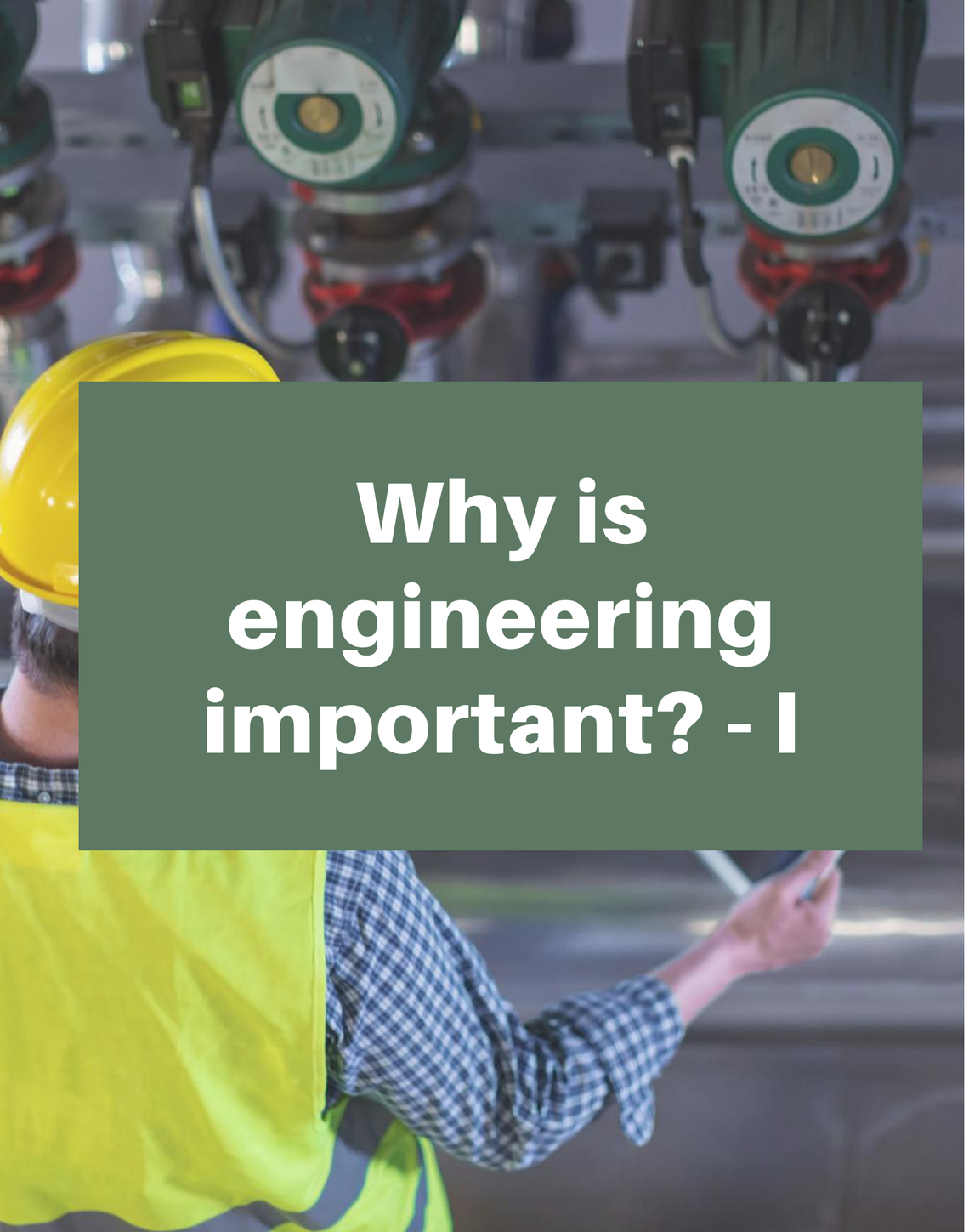


Why is engineering important?

Engineering has always changed the world for the better. It is as relevant today as ever, but more engineers with the right skills are needed. Engineering education is the key to awakening young generations about environmental problems and to achieving the 17 goals of sustainable development defined in the 2030 Agenda. Let's take a look:

1) Poverty Eradication - Engineering can alleviate urban poverty. Engineering drives economic growth and alleviates poverty through basic infrastructure such as roads, railways and telecommunications. However, there is still a long way for engineers to develop technologies that increase the availability of basic services such as clean water, basic sanitation, reliable energy and clean cooking fuels. Large populations in low-income countries require access to the latest communication, education and health technologies. Frugal innovation enables the development of technologies that are cost-effective, reliable and accessible to everyone.

2) Zero hunger and sustainable agriculture - Agricultural, mechanical and chemical engineers mechanized agriculture and food production and increased their productivity using fertilizers and pesticides. Ongoing innovations by electronics engineers and agronomists include moisture sensors whose monitoring of soil conditions optimizes the delivery of scarce water and fertilizer. Other innovations include robotic application of pesticides and fertilizers, weeding, planting, communication technology for meteorological monitoring, forecasting and warning of natural disasters. All these innovations are crucial for global food security.

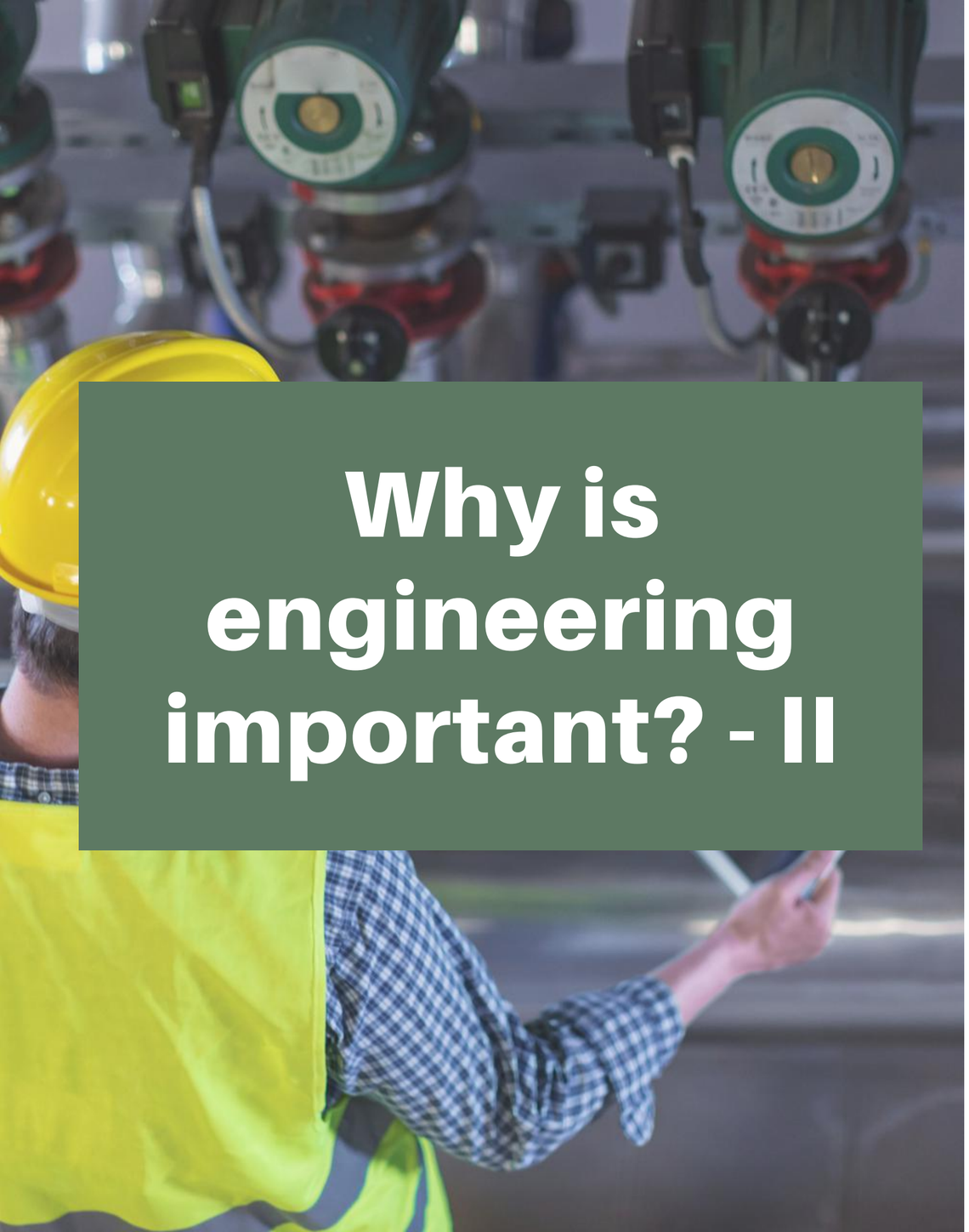


Why is engineering important? - I

3) Health and well-being - engineering has been fundamental in the fight against the COVID-19 pandemic by implementing advanced technologies such as, for example, the search for a vaccine through advanced manufacturing methods, logistics and transportation systems, and 3D printing of personal protective equipment. Engineering eradicated diseases such as typhus and cholera by providing clean water and basic sanitation. Biomedical engineering has developed prostheses and improvements in hearing, heart and brain health. Robotics, computer vision and artificial intelligence are revolutionizing diagnostics, surgical procedures and the availability of these technologies in low-income countries.

4) Quality Education - Engineers facilitate teaching at the elementary, secondary, and tertiary levels using new technologies, such as online learning tools and high-speed communication systems. This improves accessibility and reduces costs for students. Wi-Fi is deployed in more than 40 billion devices worldwide, supporting advances in education and enabling other applications. software and telecommunications engineers are rapidly expanding Internet access by using low-cost satellites and other aerial devices to provide information and services to remote, low-income communities.

5) Gender equality - ensuring women's access to technology and engineering can greatly reduce the gender gap, as well as ensure that women benefit from and participate in this revolutionary technology, fundamental to the achievement of the Sustainable Development Goals. Diversity of opinion is essential for innovation and the development of solutions that reflect the standards, values and aspirations of the community. New technologies developed by engineers are increasingly empowering women's work and entrepreneurship, including mobile communications and the Internet, which make it easier for women to access banking, financial and information services.



Why is engineering important? - II

6) Drinking water and sanitation - Civil and environmental engineers have saved millions of lives with water and sewage treatment systems, and eradicated water-borne diseases such as cholera and typhoid. Every day, electrical and mechanical engineers ensure the reliable operation of the system. Innovations in processing and recycling guarantee clean water for all, even in arid areas. despite this progress, more than 1 billion people still lack clean water and 2 billion lack basic sanitation. Urgent action, including engineering, is needed to address this challenge.

7) Clean and affordable energy - Engineering is key to the production and supply of electricity, fundamental to economic growth and improving people's living standards. However, nearly 1 billion of them – mostly in sub-Saharan Africa and South Asia – still do not have a reliable source of electricity, and securing it is a fundamental task for engineers. Electrical, mechanical and environmental engineers have played a central role in developing renewable energy solutions – including wind, solar, wave and geothermal – that are low-cost, carbon-free, make energy available to remote regions and reduce the impact of climate change.

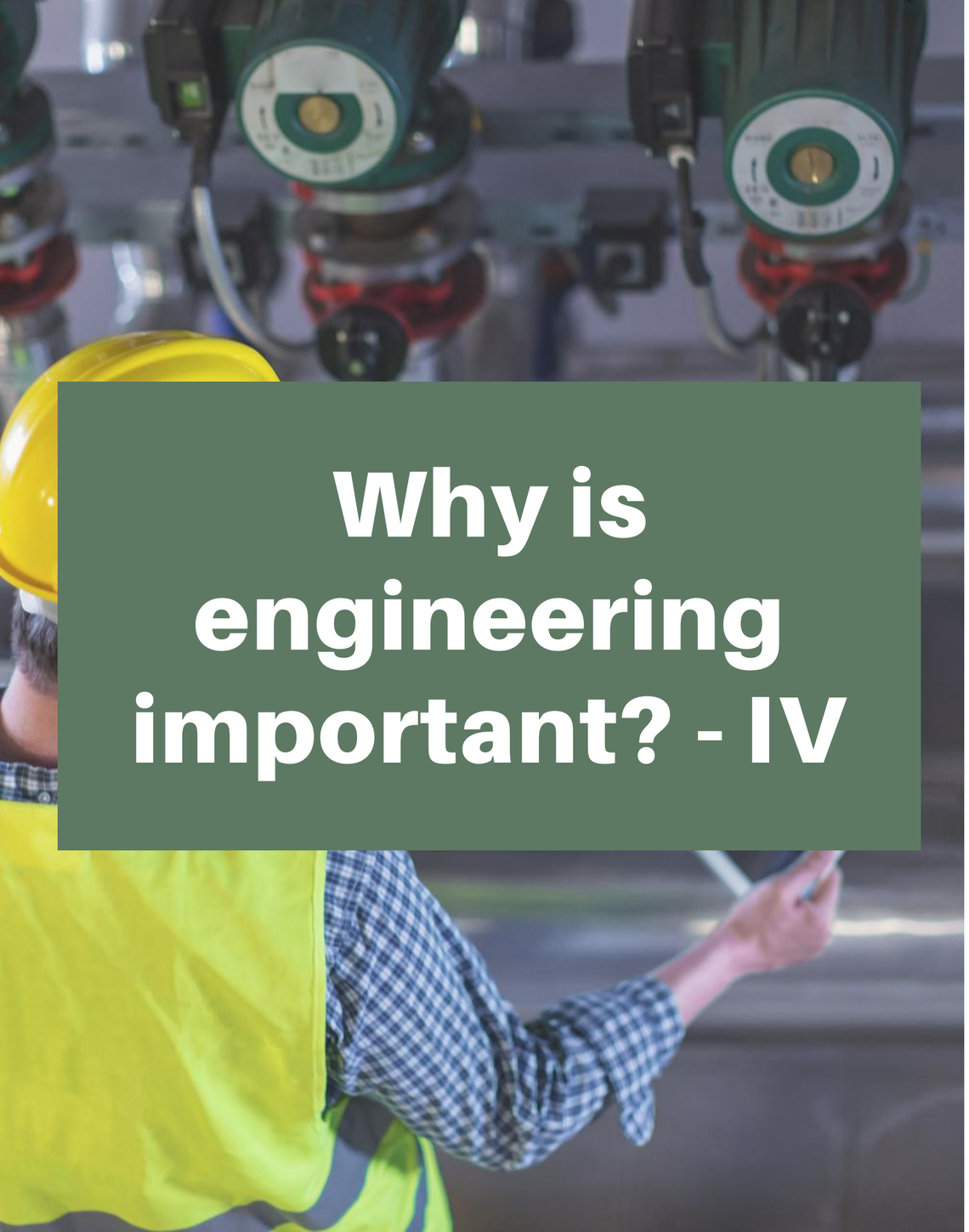
8) Decent work and economic growth - Engineering is today recognized as an important driver of economic growth, given the positive relationship between a country's economic growth and its number of engineers. Roads, railways, airports, telecommunications and water and electricity supply are part of the essential infrastructure of all economies, designed, developed and maintained by civil, mechanical, electrical and environmental engineers. You engineers are also responsible for basic amenities such as clean water, energy and housing and enable citizens to live healthy, productive lives and engage in decent work.

Why is engineering important? - III

9) Industry, innovation and infrastructure - A modern economy cannot exist without engineering. Engineers design, build and maintain infrastructure. Roads, ports, railways, communications, water supply and power systems are the work of civil, mechanical and electrical engineers. Industry needs engineers in sectors such as mining, petroleum, chemicals and food processing; therefore, all production is supported by mechanical, electrical, chemical and environmental engineers. Innovations in artificial intelligence, robotics, cloud computing and big data will drive future economic growth and jobs.

10) Reducing inequality - Through sustainable infrastructure, new technologies and innovation, engineering and engineers create jobs and opportunities that provide access to housing, food, health and a dignified life, which is fundamental to reducing inequality. Ensuring access to low-cost communications, mobile phones, information, education, medical diagnosis and treatment, especially in low-income countries, is also necessary to meet people's basic needs. Engineers develop technologies that empower women and increase their participation in the labor market, reducing chronic gender inequalities.

11) Sustainable Cities and Communities - Civil, structural, electrical, mechanical, environmental, software and telecommunications contribute to safe, inclusive and resilient cities; they also facilitate access to housing, public transport, clean air, water and energy, protect natural and cultural heritage assets, and provide greater resilience to natural disasters. Advanced technologies are used in energy-efficient buildings and resources, as well as smart city lighting, efficient transportation, renewable energy sources, integrated water resource management, geospatial engineering, building information modeling and data analytics that make cities more livable and sustainable.

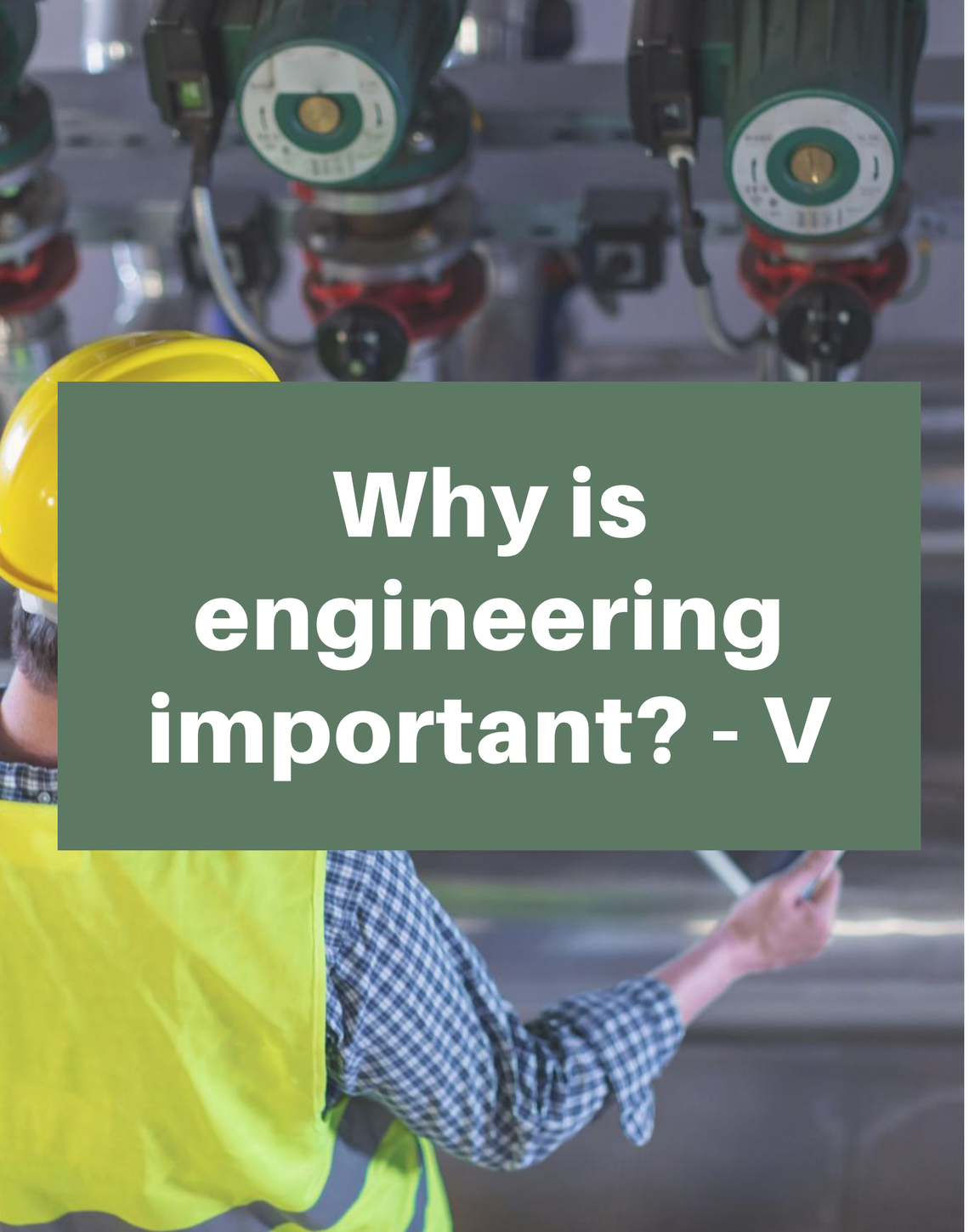


Why is engineering important? - IV

12) Responsible consumption and production - Civil, mechanical, electrical, environmental and mining engineers play a key role in the effective management of Earth's resources by processing basic minerals, producing renewable electricity, sustainable use of water resources, supporting agricultural production and managing biological diversity. That engineering innovations support resource management and responsible consumption through the "circular economy"; in which production can become an input in other processes and products. Materials scientists and chemical engineers develop innovations to recycle or reuse waste materials (including plastics).

13) Action against global climate change - Engineering enables the fight against climate change. renewable energy sources designed with zero carbon emissions include hydro, solar, wind and wave energy; in addition, green hydrogen makes energy storage cheaper. Resilient infrastructure copes with the increasing impacts of natural disasters, including cyclones and floods. Reduction of greenhouse gases through carbon capture, conversion of biosolid waste into energy and use of wood from fast-growing forests are other established actions. Other rapidly developing carbon dioxide absorption technologies include the recycling of atmospheric carbon into chemical feedstocks and the use of low-carbon building materials for housing.

14) Life on the water - Engineers play a key role in preserving and protecting the oceans and seas, as well as the life in them. environment. Marine engineers work with scientists and other engineers to address the degradation of fisheries, water pollution, oceans, and the use of its resources, including the spread of energy use. Engineers offer solutions to issues such as ocean plastic pollution and the preservation of ocean ecosystems, such as the Great Barrier Reef, threatened by climate change.



Why is engineering important? - V

15) Life on Earth - Environmental engineers manage biodiversity for responsible use of forest resources and habitat conservation. Innovative technologies map the Earth's surface and provide geospatial information used in agricultural monitoring, infrastructure design and the prediction of natural disasters such as earthquakes. These technologies also help indigenous groups and communities in vulnerable situations to increase your ability to map, analyze and negotiate sustainable development and protection of natural forests. Sensor and drone technologies can map forests and identify declining animal populations. DNA sequencing and microarrays are used to monitor endangered species.

16) Peace, Justice and Effective Institutions - Advancing the Sustainable Development Goals depends on diverse, inclusive, sustainable and ethical engineering practices. Engineers come together to develop strong institutions for the training, accreditation and regulation of engineers, which is necessary to ensure a high standard of engineering education and the competence of engineers worldwide. The Model Code of Ethics of the World Federation of Engineering Organizations (WFEO - Model Code of Ethics of the World Federation of Engineering Organizations) guides other engineering institutions. Engineers are also improving these standards to address corruption in the profession, to maximize the benefit of infrastructure investments that support sustainable development for all.

17) Partnerships and means of implementation - Engineering partnerships are essential to promote the SDGs, either within engineering disciplines or in national and international engineering institutions, including government, industry and academia. These partnerships develop solutions and plans for implementing technologies, for building capacity and knowledge transfer mechanisms, and for establishing inclusive approaches for sustainable development. World Engineering for Sustainable Development Day, celebrated annually on March 4, is an international collaborative effort to unite engineering and the community in achieving these goals.

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Chapter 4

Climate change and art

Introduction

Climate change refers to long-term changes in temperatures and weather patterns. These changes may be natural, such as variations in the solar cycle, but mostly human activities have been the main driver of climate change, primarily due to the burning of fossil fuels such as coal, oil and gas. Burning fossil fuels creates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures. Climate change is the biggest challenge facing humanity, both now and in the future. It is also a big concern for young people. According to some research, more than half of the students are worried about the climate crisis and the state of the environment. As teachers, we have a responsibility to bring climate change topics into our curriculum, not as a one-off lesson on global warming, but as a core part of our school curricula.

Talking about climate change with our students can be difficult for many teachers. Students can feel many emotions about climate change, such as anxiety, fear, sadness, and anger, which are very natural reactions to something as uncertain and devastating as climate change. Talking about climate change can help them discover the facts, know they are not alone and find ways to take action. One of the easiest ways to do this and very close to students is through art.

Traditionally, when talking about STEAM education, many people only talk about the main pillars of the curriculum: science, technology, engineering and mathematics. However, in recent years there have been efforts to transition STEM to STEAM – adding the letter "A" to the acronym to represent the arts. Although STEM education has always included the arts in the curriculum, the effort to change the acronym emphasizes the importance that arts education has on a child's personal and academic development.

When art education is mentioned, most people think of painting, drawing, or playing an instrument, but art education is much more than just expressive art. It also includes subjects such as history, social studies, and language arts, all of which are essential aspects of STEM/STEAM education. A comprehensive arts education program develops the critical skills of communication, innovation and creativity together. Expressive art, which can appear in many forms including sculpture, painting, and music, is also an important component of academic success and the achievement of higher learning skills.

Introduction - I

One of the essential principles of teaching students about climate change is the message that it has consequences for the Earth and human lives. Many students want to take an active role in the fight against climate change and are interested in how they can do this in the classroom. Teachers have the opportunity to incorporate elements of climate change into their lessons to ensure that these students have the knowledge they need to address the issue in whatever capacity they see fit.

Climate change affects people and the natural environment today, and will especially affect the future. The visual arts provide tools for instigating social change and processing and overcoming the emotions that come with climate change. Instead of a passive approach, art encourages us to engage and act. Therefore, visual art plays a key role in the in-depth understanding of climate change and the creation of a climate-friendly world.

Teaching art and climate change

Art is a powerful form of communication that helps children better understand complex topics such as climate change. Teaching about climate change in, with, and through the arts is an effective tool for teachers to help children learn about this global issue, help them see solutions, and express themselves.

Teaching in art

Teaching climate change in art means teaching climate change in art classes. Art is used here to introduce students to climate change, teach basic concepts and help them learn more about the issue. Creative media such as comics, infographics, documentaries and other artworks can be used to provide students with different perspectives. As the arts communicate with different audiences, teachers can support multiple learning styles and help students better understand the many issues caused by climate change.

Teaching art and climate change - I

Teaching with art

Teaching through art means that students use art to express content and initiate discussions to share their thoughts and feelings about what they have learned. This helps them develop creative and critical thinking skills. It is a nice addition to teaching art, as students not only listen, but also interact with the learning content, for example in art and science labs. In such laboratories, they can develop concepts for their final work of art. This helps them gain a deeper understanding, so they can develop solutions and take action outside the classroom.

Teaching through art

Teaching through art means that students share their art to create an experience for the viewer. For example, some students show a picture and others a theater performance to encourage the viewer to question what they know about climate change. It gives students the opportunity to tell the story of climate change from their perspective and share ideas that can make a positive impact.
So art can be used to teach children in art classes about climate change and related issues. When they are in these classes, they themselves create art, develop a deeper understanding. And when they then share their art with others, they can make a positive difference to others as well.

Why is art important?

Teaching art is not only a way for children to be creative – it is also an integral part of developing students' higher learning skills. A program that incorporates the arts into the curriculum has been proven to increase creativity, improve academic performance, increase motor skills, improve visual learning, and encourage better decision-making skills.

Increase creativity

By allowing students to explore their expressive side through art, they can expand their creative thinking skills, which are essential for solving complex engineering, science, and math problems. These creative thinking skills teach your students to think outside the box and explore different, non-traditional paths to solutions.

Improve academic performance

According to a report by Americans for the Arts, children who engage in the arts, defined as three hours a day for at least three days a week, are four times more likely to be successful academically than children who are not.

Increase motor skills

By engaging in expressive and creative art, students develop better hand-eye coordination and fine motor skills. What physical exercise does for gross motor skills, art activities can do for the more complex and fine motor skills needed in all aspects of life, from handwriting to connecting robotics.

Why is art important? - I

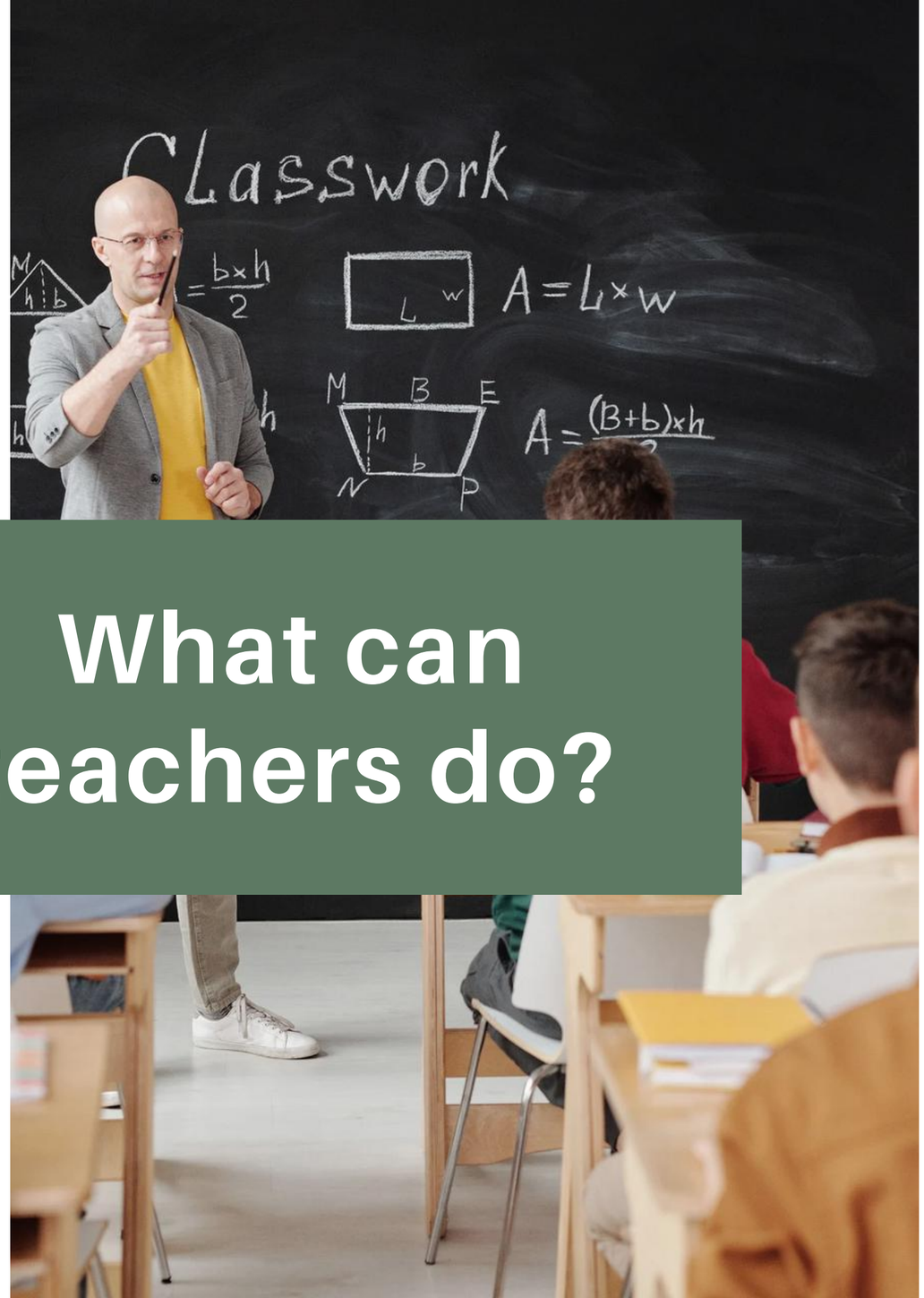
Improve visual learning

Students who are familiar with different artistic media, such as sculpture and three-dimensional exploration, are better able to make sense of visual information. According to the head of the Department of Art and Design at Northern Illinois University, visual learning is just as important as auditory learning, and it's a skill that not all students develop without expressive art classes.

Enhance higher decision-making skills

Being able to explore the creative side of the brain through art allows students to make their own decisions about how to interpret and communicate their ideas. Art is a key component to improving a child's ability to make decisions and express themselves articulately.

Art is believed to be a necessary part of every student's education. From preschool to high school, aspects of social studies, language, arts, and creative arts should be included in every school's STEAM and climate change curriculum.



What can teachers do?

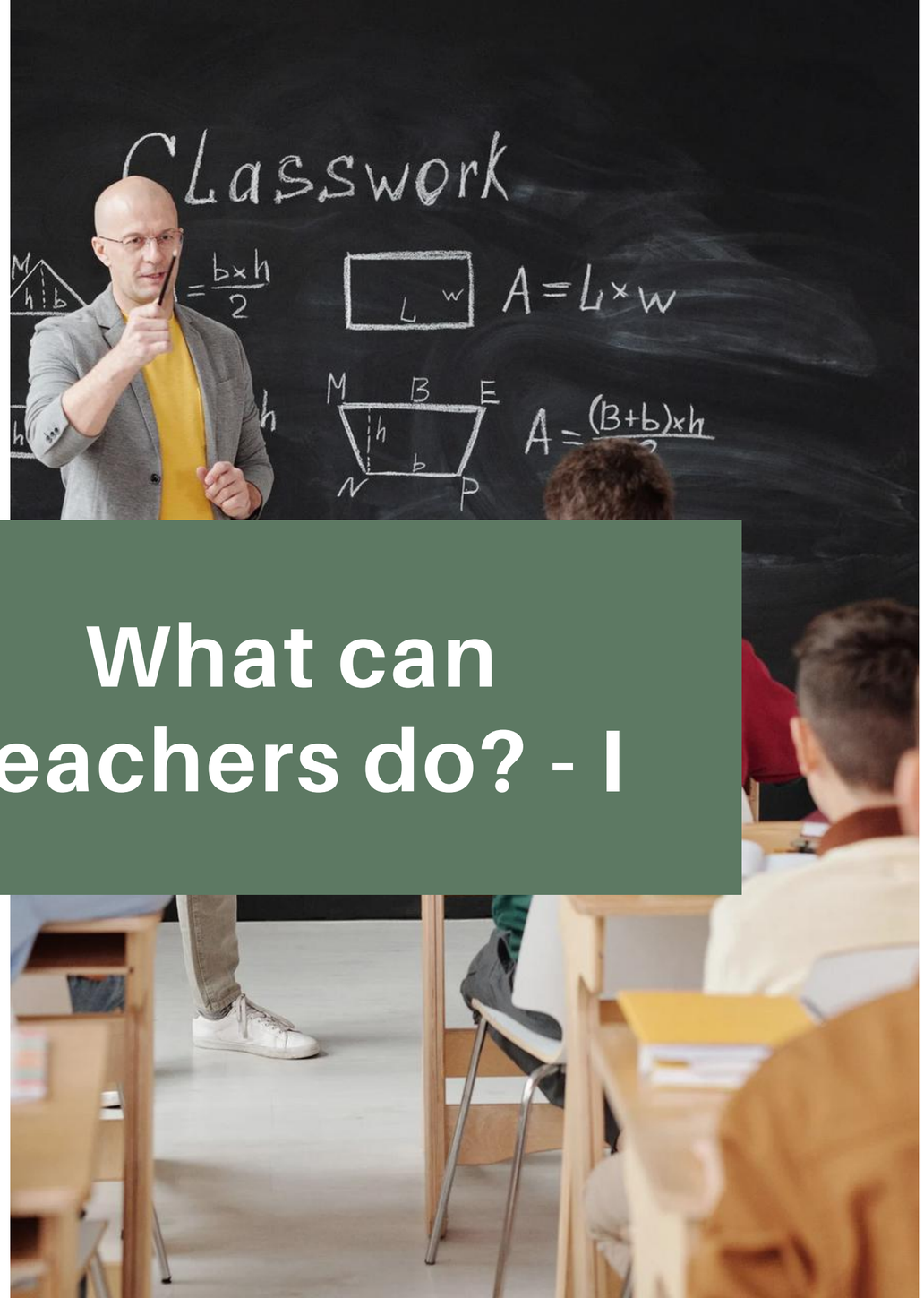
Art teachers are in a unique position to explore topics in a way that allows for curiosity, questioning, and personal exploration. Climate change provides an opportunity for teachers to engage students in the topic and inspire attitudes that could change the world. In this process, they should follow some basic rules.

Make the lessons non-judgmental

We know that students will come to class with different starting points. However, when teaching about concepts such as climate change, it is important to reflect on our own position and recognize that some students may know more than we do. Climate change is a passionate topic for many young people and it is important that we are ready to listen. However, some students may not be so sure. The element of anonymity also allows students to be honest because they will be free from judgment. Furthermore, some students may come to lessons with ideas about the problem of climate change inspired by fake news or other celebrities. For example, in 2018, Donald Trump said that he does not believe in climate change. As an educator, it is critical that you listen to all viewpoints and be prepared to discuss them.

Avoid creating climate anxiety

Climate anxiety is a form of psychological discomfort caused by the climate crisis. With severe mental health on the rise among young people, it is important that we try to avoid contributing to this by increasing feelings of existential dread. The reality of climate change is that the real impact will not be felt until well into the future. This is why young people are particularly vulnerable to climate concerns; therefore, it is important to choose the material carefully. Try to avoid sources that can scare or cause panic. Creativity will be a useful tool for students to express their frustration about the topic, so be prepared to see a range of works from sad to humorous!



What can teachers do? - I

Explore the materials

Climate change doesn't have a preferred artistic medium, and that means you can really be exploratory. Always allow students to express their feelings through their art. Try not to be too restrictive and allow students to explore their own personal style. The selection of materials also offers you additional opportunities to probe and encourage students to think about the materials they are using. Climate change is a challenge that isn't going away anytime soon, so it's important that students recognize the problem and know how to deal with their feelings surrounding it.

Talk about famous people

Climate change is a hot topic that has seen various celebrities regularly campaign to take real action for a better future. One of the most significant figures of recent times is Greta Thunberg. She led the "Fridays for the Future" campaign movement in which thousands of children went on strike on Fridays, asking political leaders to take action to prevent climate change. Greta took on these campaigns as a teenager, making her a great ambassador for children learning about climate change.

Sir David Attenborough is another name synonymous with conversations about the environment and climate change due to his lifelong work to save the planet and its incredible wildlife. His recent television series, Blue Planet, is a great example of highlighting the issue of single-use plastics and is the perfect series to teach children about what is happening around the world.

Example of an activity: Creating an eco city

Students will create a model of the Eco City. To make the model, students will use recycled materials such as paper, plastic, fabric, etc. The model should be at least 70 x 50 cm long. It should contain all the buildings and other parts that an Eco-city should have. Before starting the activity, the students discuss with their teachers about their vision of the Eco City. Some of the issues that can be discussed are:

What is an Eco City?
How should people become Eco-citizens?
How can a city become an Eco city?
What are renewable energy sources?
What is the goal of waste sorting?
How to create an eco plan of the city?
What can students do to make their city an Eco city?

After completing the introductory part, students will use different materials to:
Make a sketch of an Eco-city,
Make all segments using recyclable materials,
Use cardboard for the city surface,
Organize the city and make it real,
Design a poster and slogan for your Eco City,
Compose the anthem of the Eco City,
design the coat of arms of your Eco City,
Make a video with a model explaining why it is an Eco city.

Students can organize a meeting with the mayor and present their final video product of their Eco City model. Students can present possible innovations in their local community to make their city more Eco-city.

Example of activity: Art Eco

The teacher will organize an art workshop where students will make brooches. Each brooch will be made from recycled materials such as paper, fabric, etc. There are many topics within climate change studies that can be used for this activity. For example: endangered animals or plants. Each brooch will represent an endangered animal or plant of the students' choice.

Before starting the activity, the students talk with the teachers about endangered species. Some of the issues that can be discussed are:
What are the endangered species?
What are the threat levels?
What are the most endangered species in your country?
Why are species endangered?
What is a seed vault?
What is a botanical garden?
How can people help plants not become endangered?

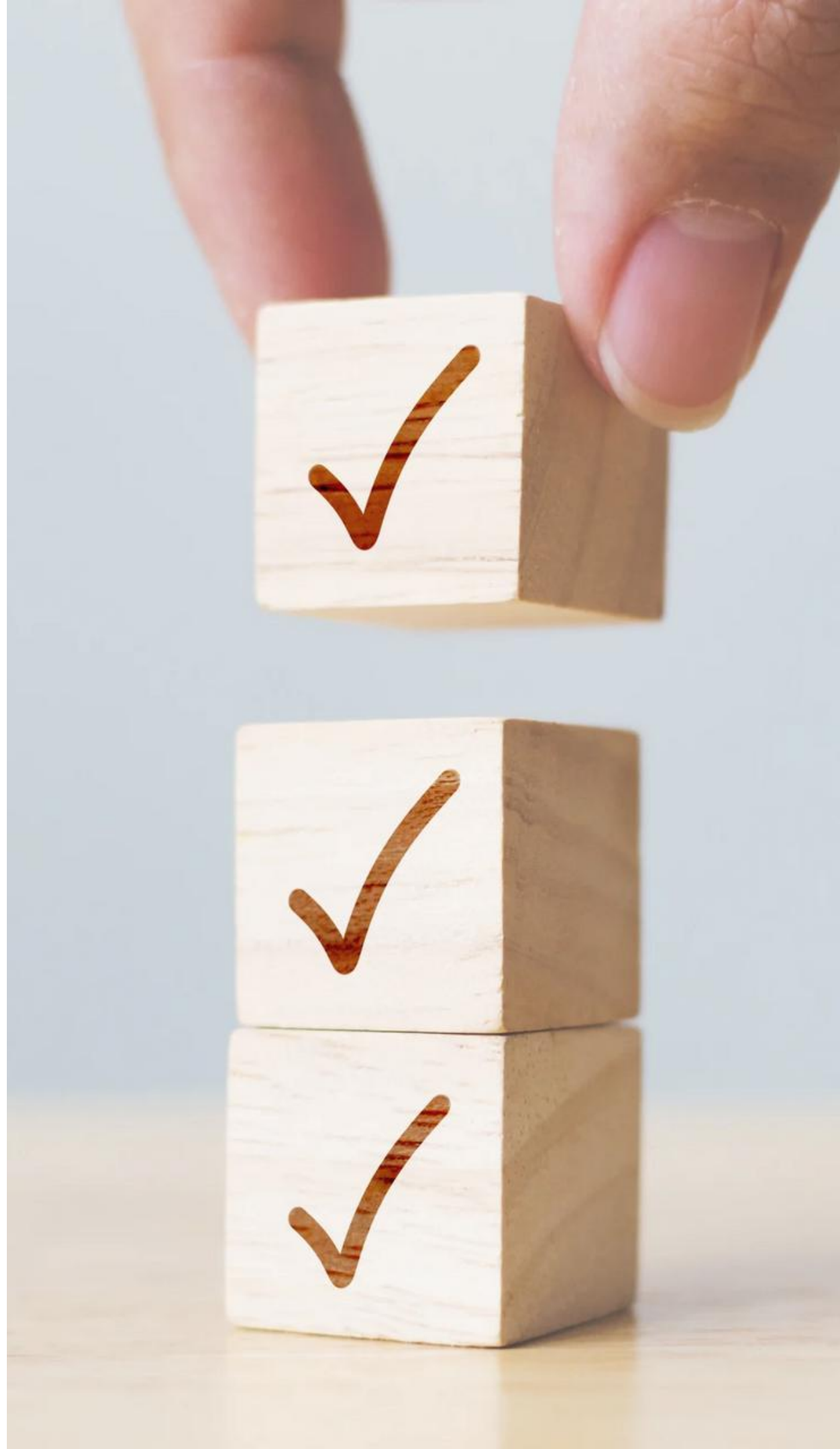
After completing the introductory part, students will use different materials:
cut out a cardboard circle to make a brooch,
decide on the endangered species that will be presented on the brochure,
cut the different materials used for the brooch,
stick them on cardboard,
place the pin on the back of the cardboard

At the end, an exhibition can be organized in the school corridor. A visit to a botanical garden, nature park or national park can be organized before or after the activity.

Concluding remarks

Art has inspired people and planted seedlings of ideas in our minds for centuries. She helped us come to terms with reality and imagine an alternative future for ourselves. It engaged our hearts and minds - something that climate action has so far failed to do. Art inspires that emotional connection that allows people to see how close climate change is and how much power each of us truly has in the fight against it.

Most importantly, using creativity and the arts to drive climate action means giving power back to the most vulnerable players: women, children, indigenous communities and developing countries. It levels the playing field by keeping giant corporations out of the game and is arguably one of the universal modes of global communication. When artists come together to inspire climate action, new levels of mass change that we previously thought were impossible can become a reality if we meet people where they are through what they love most: art and creativity!



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Chapter 5

Climate change and mathematics

Introduction

Climate change is the overriding threat to humanity and the natural environment in this decade, and based on our failure to tackle climate change badly, it will retain its status as a threat well into the future. Mathematical expertise plays a significant role in creating knowledge about climate change, understanding it as a phenomenon and contributing to the climate debate from a different perspective. Therefore, mathematics is very important for building a climate-friendly world by educating critical thinkers, active citizens and young scientists.

Scientists discovered the first signs of climate change about 100 years ago. From then until today, knowledge about the topic of climate change has increased, but it has also become a more serious problem. Although the realization is there, there has been a lot of delay in developing mitigation strategies and techniques.

Learning mathematics is an absolute stimulus to abstract thinking, which is an essential tool for anyone dealing with climate issues. Together, weather and climate create a complex system that is continuously affected by the development of the atmosphere, oceans, glaciers and land. The climate of a certain area is determined by the average weather conditions over a long period of time, which means that climate refers to weather statistics and therefore climate change is a statistical phenomenon. Thus, climate science largely requires the application of mathematics.

Mathematics is essential for describing and projecting climate change and communicating these materials. In order to describe climate change, we must first identify what is "normal". For this purpose, we need to calculate environmental measurements concerning temperature, precipitation, snow cover, sea level, amount of carbon dioxide in the atmosphere, and so on. By calculating the average, analyzing the variance and creating a diagram, we can find out if the climate has changed and how.

Introduction - I

Forecasting possible climate scenarios requires mathematical modeling using differential equations and stochastic methods. Climate models are complex entities and require, among other things, different types of modeling of the atmosphere, oceans and clouds, and modeling of their interconnections. This allows us to obtain numerous estimates of possible climate scenarios in the future. Models that can be created with the help of mathematics are useful for decision makers, companies and active citizens who want to take action to reduce the effects of climate change.

Climate knowledge in relation to mathematics can take the form of texts, charts and diagrams. Communicating this complex information within the scientific community and among decision makers, planners, and the public requires an audience that is mathematically literate. Therefore, the transfer of knowledge about the climate requires mathematical skills in both producers and consumers of this knowledge.

For energy sustainability alone, mathematics can contribute a lot to finding better and less polluting ways to explore new energy, increase combustion efficiency, develop alternative energy, manage energy grids and networks, and reduce the climate consequences of energy use. For the sustainability of financial markets and economic systems, the role of mathematics is equally ubiquitous and essential.

Teaching mathematics and climate change

Barwell and Hauge (2021) propose 3 principles that are derived from theoretical ideas, mathematics classroom tasks, classroom observations, and a survey of teachers in Norway and Canada (Abtahi et al., 2017). These principles are forms of authenticity, forms of participation and thinking about mathematics and with mathematics. These principles are a kind of starting point for connecting the teaching of mathematics with climate change, rather than a definitive set of empirically validated standards. Their interpretation, implementation and modification may vary from site to site or classroom to classroom.

Teaching mathematics and climate change - I

1) Forms of authenticity

Climate change affects the whole world, but this phenomenon seems rather abstract or diffuse. It is quite difficult for individuals to "see" climate change. Therefore, it is extremely important that students authentically deal with climate change in order to come to an understanding of its concrete impact in the present time or in the future.

Using climate change issues that students find relevant to their lives is the first of four principles related to authenticity. In many cases, the problems of climate change can be simplified through local climate problems and issues. For example, research on local climate change, local greenhouse gas emissions or local climate change impacts, such as flooding, local biodiversity or commercial interests. In other cases, students might freely identify problems arising from their own interests and engagements with related topics. For example, interest in animal welfare should be translated into a focus on the Arctic ice sheet in relation to the predicted extinction of the polar bear population.

"By working on relevant problems, students are more likely to perceive and consider the complexity of those problems" (Appelbaum, 2009; English & Gainsburg, 2015; Kaiser & Schwarz, 2010).

Students should work with real data as much as possible. Real data can be obtained by students through observation or surveys and publicly available data sets such as climate data, data on greenhouse gas emissions and others. The teacher's role in this scenario is to support students in accessing and filtering data: large online data sets can be unwieldy, and teachers may need to make some initial selections or help students make such selections.
Students should have the opportunity to engage in meaningful discussion about climate change based on their mathematical investigations.

"Through the thoughtful use of mathematics, students can develop a deeper, critical understanding of problems and clearer thoughtful responses" (Appelbaum, 2009; Hauge & Barwell, 2017).

Teaching mathematics and climate change - II

2) Forms of participation

This group of principles stems from the need to prepare students to contribute to an extended community of peers. Therefore, they should be exposed to the communication of mathematical ideas and the use of mathematics in discussions and deliberations.

Students should participate in mathematics. This participation should not be passive, students should be active which means doing more than just solving problems given by the teacher. They should actively choose problems, mathematize problems, choose data, choose mathematical tools, etc. Active participation in mathematics is fundamental to thinking about mathematics.

Students should actively participate in their classrooms. Participation can include both individual and collective participation. But the collective is desirable: students can work together in small groups, share their work with classmates, discuss the work and criticize the work of others, and reflect on the findings of others. In case students have problems working together, it may be necessary for teachers to intervene and structure their participation in order to increase the productivity of collaboration.

Students should actively participate in their communities. These communities may include their school, neighborhood, or math communities. Climate change research is not only an interesting context for learning mathematics, but their work can affect many aspects of school life and the life of the surrounding community, such as in relation to energy consumption, traffic patterns or local political action. For example, students can collect data by asking older people in their community about their experience of climate change.

Students should actively engage and participate in the public debate. Public media can provide many starting points for mathematical activities. Students can present their findings as responses to positions presented in a public debate, supporting, refuting or criticizing different opinions.

Teaching mathematics and climate change - III

3) Thinking about mathematics and with mathematics

The principles under this topic mainly derive from the idea of critical mathematics education that students should understand the role of mathematics in the formation of their society and personal life, in addition to understanding the role of mathematics in understanding problems such as climate change.

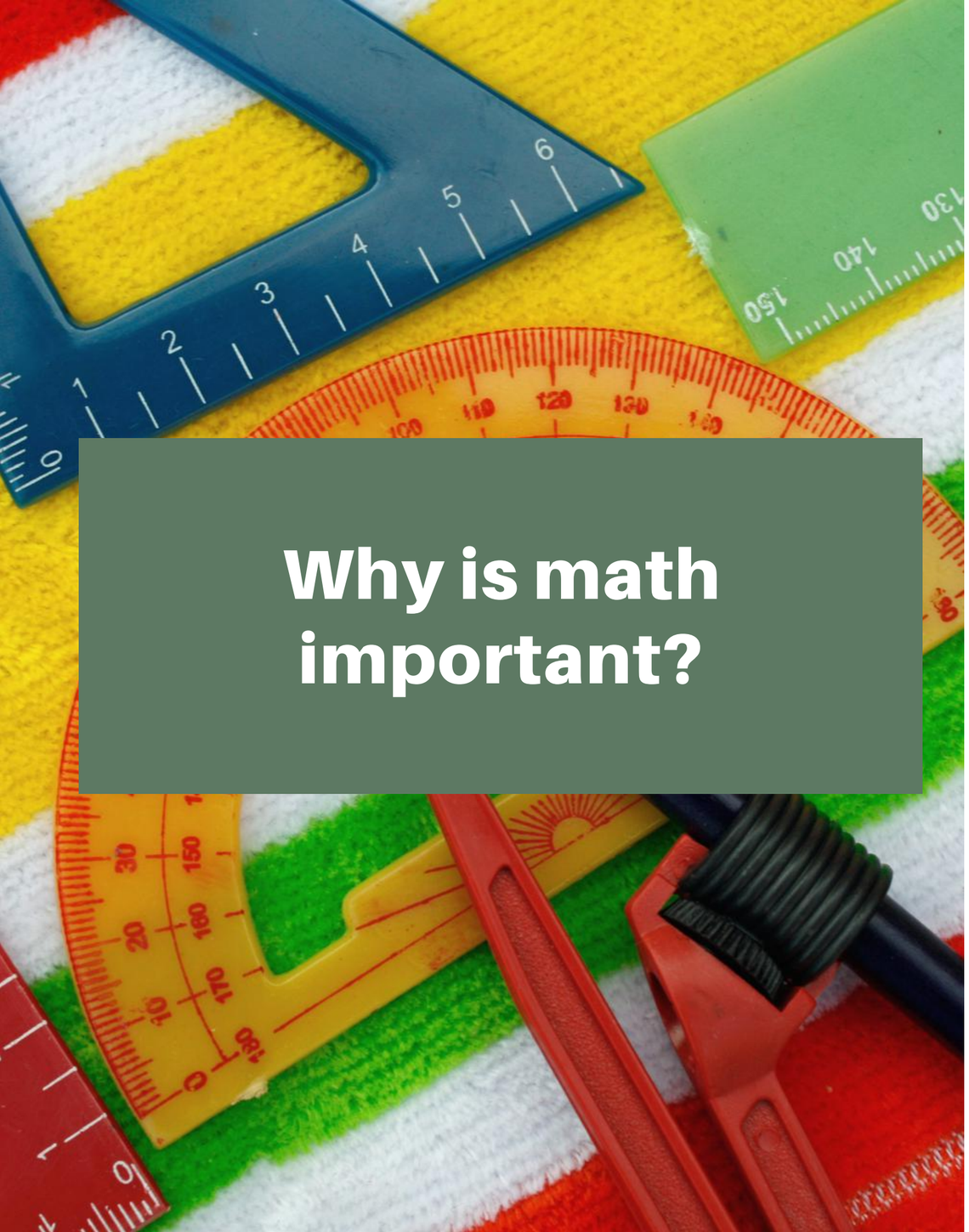
Students should have opportunities to think about how useful mathematics is. Through creating authentic tasks and engaging in various forms of participation, students should develop a valuable sense of what is possible with the help of mathematics. For example,

math can clarify an underlying warming trend in jumbled temperature data that would otherwise be difficult to observe, and certainly difficult to physically experience in many places.

Students should have the opportunity to think about the limits of mathematics. By following their efforts on authentic tasks, students should have a sense of what mathematics cannot do. For example, mathematics cannot model: emotions such as the feeling after your house is flooded, the significance of the disappearance or extinction of fish or insect species resulting from increasing warming levels in the oceans.

Students should consider the role of values in mathematics. Students should consider how values shape project selection, data selection, and interpretation of findings. For example, in a project on climate impacts on local farms, some students may be motivated by economic reasons, such as loss of income for farmers, while others may be motivated by concern for biodiversity.

Students should have the opportunity to think about uncertainty and consider ways to deal with it. Through their authentic activities, students are more likely to encounter different types of uncertainty, including the inherent level of imprecision in their data, the absence of some type of data, and the possibility that unrecognized factors are influencing the situation.



Why is math important?

There are papers documenting the introduction of sustainability into subjects such as science or language teaching. However, there is little research that explores the fundamental role of students' mathematics education in learning different aspects of climate change and achieving sustainable development. In addition, the School Education Gateway survey on climate education found that only 4% of students felt they knew a lot about climate change.

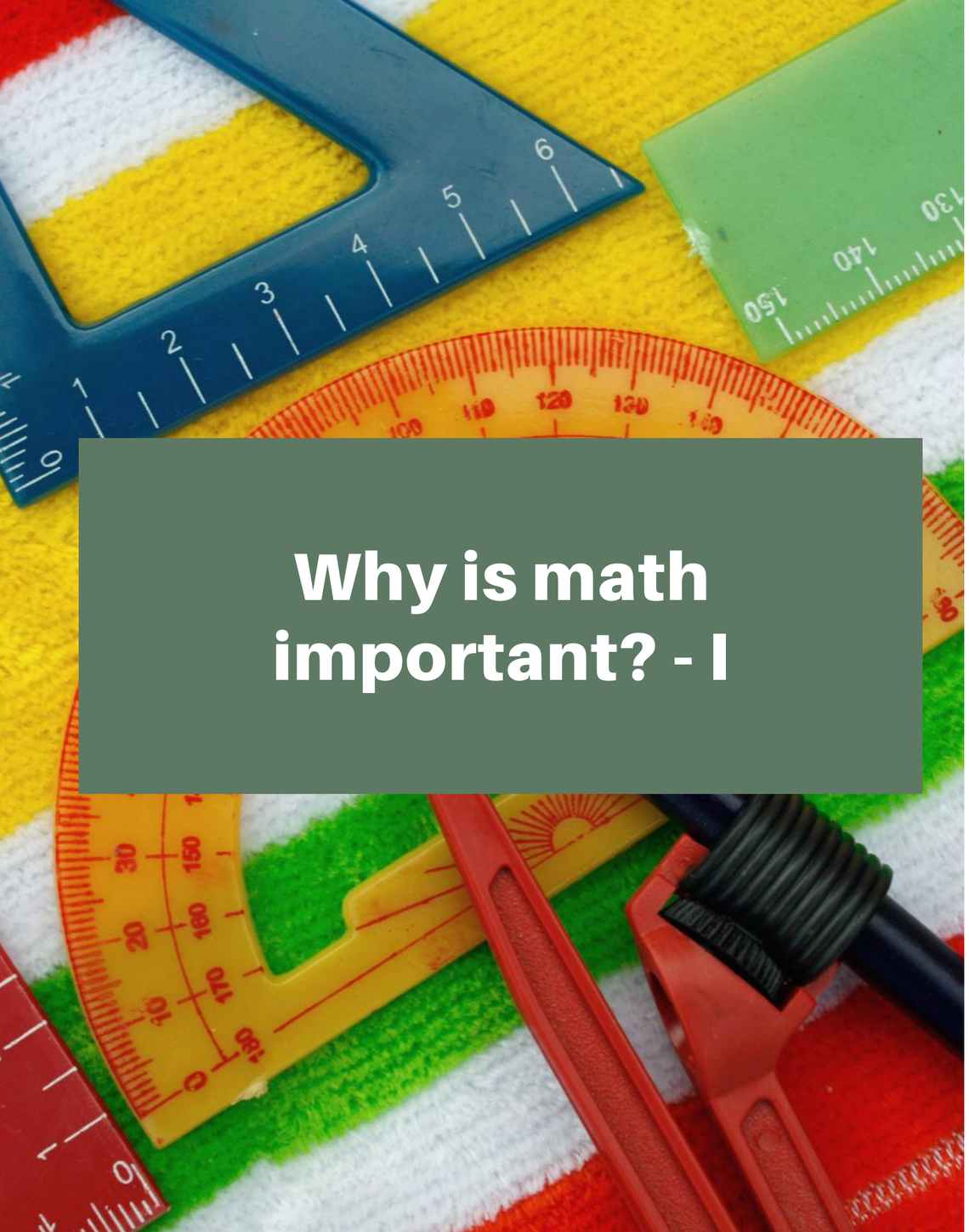
Mathematics can be an important tool in understanding the information we receive, and teachers have an important role in this positive change. So, what is the significance of mathematics in teaching about climate change?

Without numbers, students would not understand ideas like the carbon budget or limiting warming to 1.5 degrees at the heart of the climate change debate.

Without using data to think abstractly, our senses and observations alone would not confirm that climate change is occurring or that we need to act.

Climate change is also a statistical phenomenon that is understood by mapping changes in average measurements (for example, temperature, sea level, or snowfall) over time and analyzing variance to provide compelling evidence of changes in the global environment.

Different mathematical processes need to be used to provide these measurements and build models to predict what the situation might be in the future.

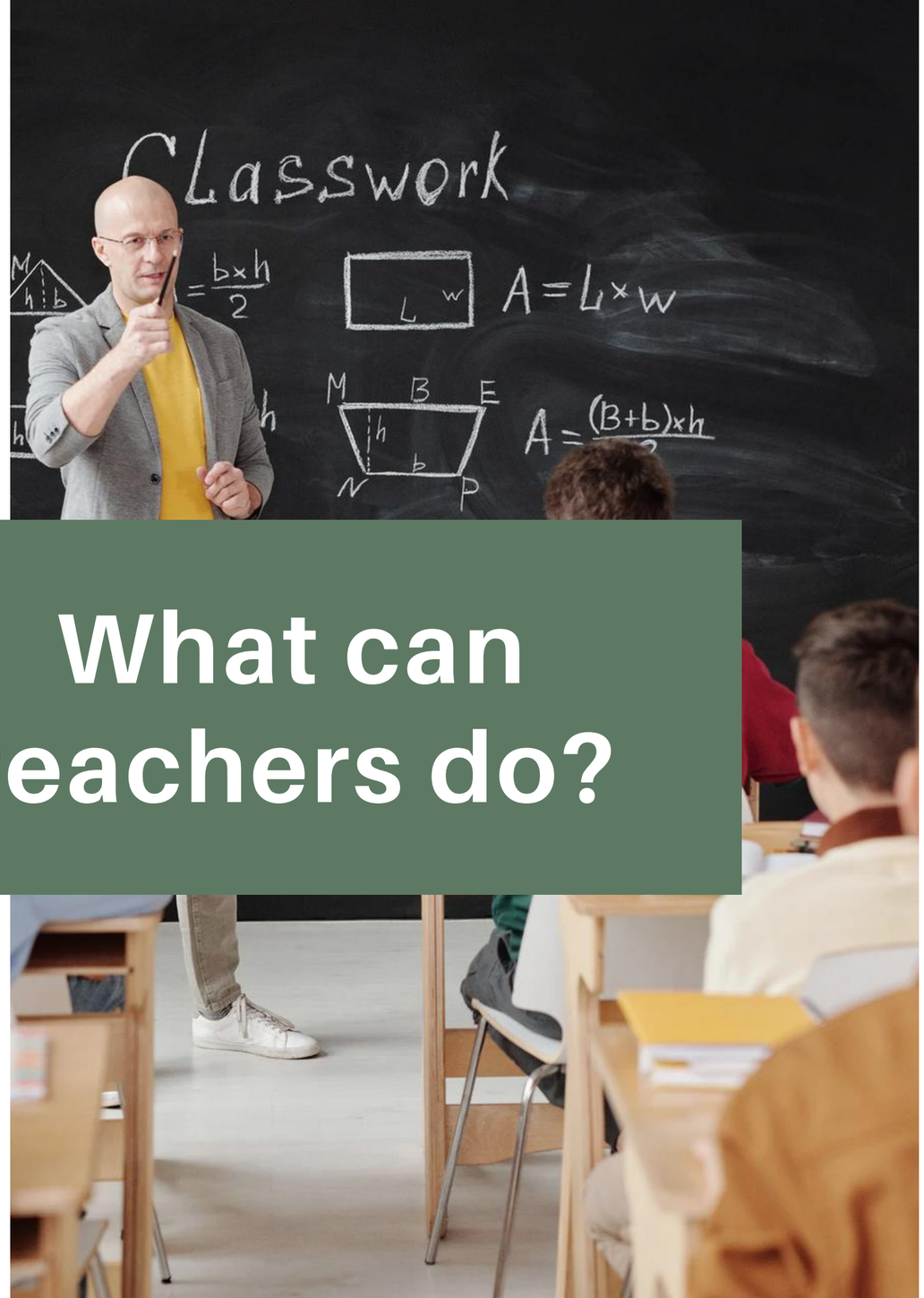


Why is math important? - I

- Decision makers and the public alike need a mathematical foundation to understand this type of information, for example through mathematical diagrams.

- Citizens must be able to determine how to be critical of the data in order to align their behavior with the data they trust and move beyond the data presented with an agenda.

- Most students find it difficult to understand the usefulness of mathematics and describe it as a complicated subject. While some students have a positive perception of mathematics because they think that it is used in everyday life, others perceive mathematics as an isolated set of procedures with no application in real life, which alienates them from learning. Innovative practices play a significant role in convincing this group of students and increasing their performance by changing their perception. If students are convinced that mathematics is indeed useful in solving problems they face in their daily lives, it would be easier to extend the solution to wider problems, in this case climate change.



What can teachers do?

Our understanding of data, as well as its processing, is fundamental to making good political decisions. The role of mathematics teachers is extremely important in achieving the prevalent basic climate literacy of students.

A simple first step for young students in understanding climate change would be to calculate their carbon footprint. This footprint calculator can start a discussion about what variables affect carbon emissions, what choices we have control over, and what aspects of climate policy we need to advocate at the societal level.

Analyzing data on natural phenomena is a natural entry point for mathematics teachers in approaching climate change. From weather patterns to changes in local biodiversity to sophisticated modeling software, there are appropriate datasets for every age group. Classroom-ready data sets in environmental math offer shorter and longer problem sets, and this Connecting Data to Storytelling lesson helps students connect short audio stories to specific map data.

With the help of the EnRoads climate solutions simulator and a guided assignment, students will have the opportunity to manipulate a range of variables to present a scenario that can mitigate the impact of global warming to the internationally agreed goal of below 2 degrees by 2100. Through this focus on policy-level solutions, students can understand the extent of change that can be achieved and what the obstacles are for their generation.

Example activity: Go back to your birthday

In order for this activity to be carried out successfully, historical weather data should be available online. Through this data, participants can select a specific date in a specific year, in this case their birthday, and check what the weather was like.

The premise of this research is that students search for temperature data (or other weather data) on their date of birth and place of birth (or current place of residence), for each year of their lives, and go back in time. It is desirable to strike a balance between working on clean datasets and struggling with complex databases. After eliciting data, students should be given a certain level of autonomy to explore it. Possible activities are the calculation of averages and the creation of graphs of temperatures over time. Students can work with real data, they can also lead a discussion about which temperature data to include in the graph: mean temperature, temperature at a certain time of day or others. Additionally, students can also discuss whether to work with averages such as mean daily temperature, mean decadal temperature, or mean temperature anomalies. Therefore, students will eventually gain knowledge about global warming and temperature trends.

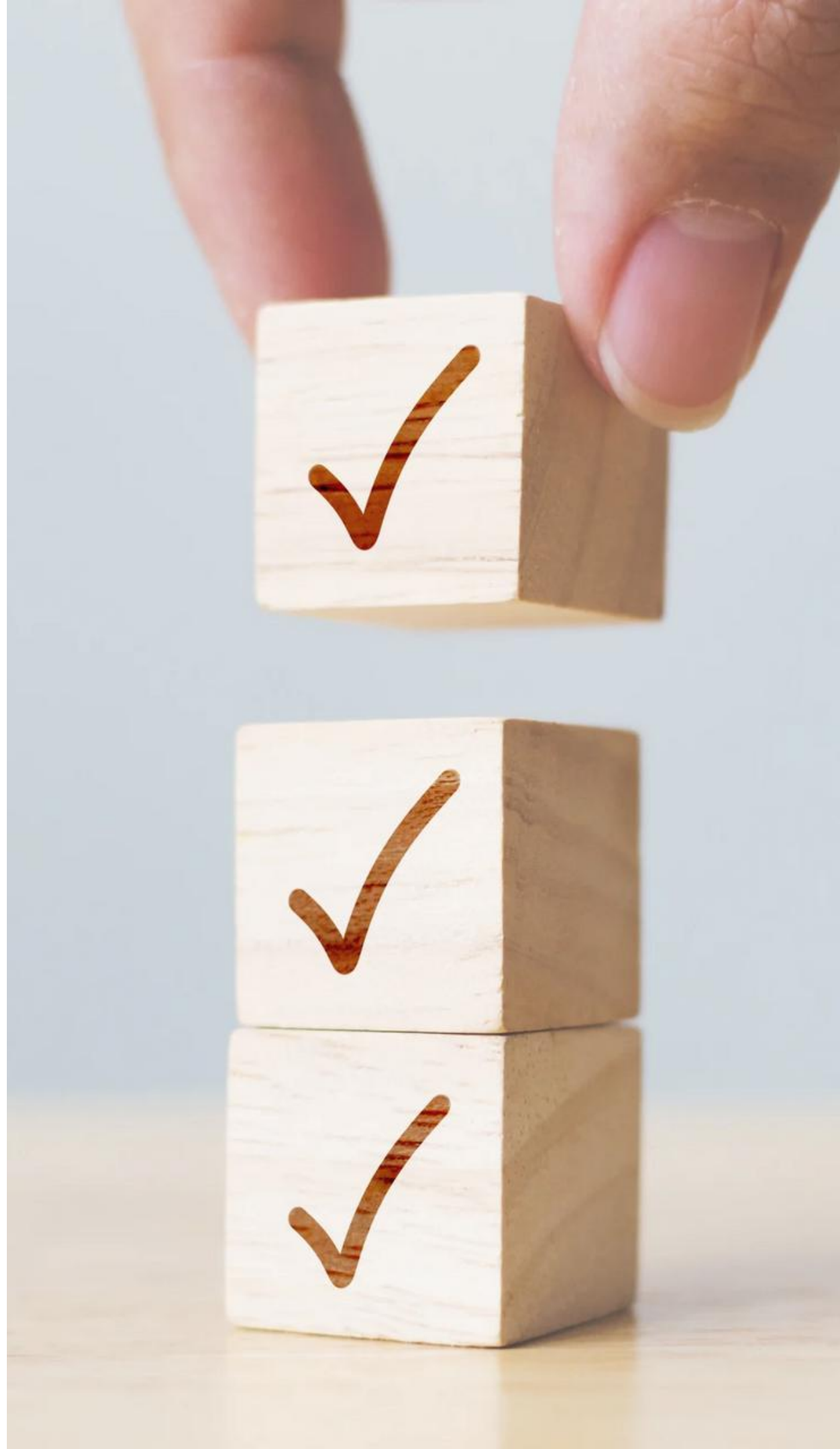
It may be enough to draw on their experiences to discuss variations in the weather, what affects the weather, what the trend is, and the difference between weather and climate. In addition, students' data and analysis can show global warming. Through this, students can think about the usefulness of the data and the ways in which mathematics has been applied to show different pictures of how temperature has changed over time. Students also realize areas or ways in which math does not help at all.

After completing the initial tasks, students can be encouraged to generate further questions through brainstorming. They could compare temperature trends on the birthdays of two or more students; investigate how temperatures have changed, possibly investigate other data, etc.

Concluding remarks

Climate change is not talked about or dealt with enough in the teaching of mathematics, in the mathematics curriculum and in mathematics education research. However, mathematics is very important in many aspects of climate change because we need to include a set of data, statistics to somehow make this looming global problem concrete.

Through involving students in different forms of authenticity, different forms of participation and in different reflections, students will be able to develop a critical understanding of the basics of climate change as well as the role of mathematics. Students must prepare for the future because they will suffer severely because of the actions of previous generations. Therefore, teachers play a key role in preparing these future citizens by helping them understand the role of mathematics and its limitations regarding the difficult decision they will have to make.



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Chapter 6

Community science projects

Introduction

Climate change represents a significant threat to modern society. Global warming, water shortages and rising levels of greenhouse gas emissions are just some of the threats we will have to face if significant measures are not taken. The impact of climate change is felt all over the world, and even Europe is not immune to its effects. The consequences of climate change are far-reaching and can have severe social, economic and environmental effects.

The past decade was the warmest on record (Climate Change: Global Temperature, 2023), as Arctic temperatures are rising faster. Natural disasters such as devastating storms have become more frequent and intense, exacerbating extreme rainfall and flooding. Climate change is also making water scarcer in many regions, threatening food supplies and increasing the risk of drought (Gerretsen, 2023). Furthermore, the ocean absorbs most of the heat from global warming, leading to rising sea levels and endangering marine life.

Climate change is driving species loss, which will have far-reaching consequences for ecosystems and human well-being. Poor nutrition and health risks are also increasing due to climate change, which can lead to increased poverty and displacement. (United Nations, 2023) It is therefore imperative that we take action to mitigate the effects of climate change.

A thorough, interdisciplinary approach is needed to address the range of problems brought about by climate change. STEAM-based learning, which stands for Science, Technology, Engineering, Arts, and Mathematics, has emerged as an effective teaching method for developing critical thinking, problem-solving, and innovative skills. Community science projects against climate change, involving collaborative, hands-on and real-world problem solving, provide an excellent opportunity for students to apply a STEAM approach to solving (local) environmental challenges. By engaging in social science projects, students can develop an understanding of climate change, learn about the impact of human activities on the environment, and contribute to the development of solutions. In this context, STEAM-based learning using community science projects against climate change can be an important tool for promoting environmental awareness, building sustainable communities, and preparing future generations to face the pressing challenges of our time. Education and involvement of students to become active participants in the fight against climate change has a key role. By empowering students with the necessary knowledge and skills, we can work towards a more sustainable and resilient future for ourselves and future generations.

Community scientific projects in teaching and climate change

Education plays a key role in dealing with climate change now and in the future. Numerous studies have shown that the best strategies for improving citizenship education are through classroom instruction, extracurricular activities, school culture, and service learning. As a result, schools should create appropriate policies for citizenship education and guide teachers to provide appropriate curricula and activities to foster students' sense of citizenship and civic involvement (Ng & Man, 2022). The STEAM approach to teaching is a way to incorporate interdisciplinary methods into the classroom to enable students to gain a deeper understanding of material and apply it to real-world problems. Instead of waiting for teachers to answer, STEAM education can encourage students to think for themselves. Because the world requires these kinds of thinkers to address issues like climate change, the primary goals of STEAM education are to equip children with critical thinking and innovative ways of thinking. To help students understand people's needs and devise plans to meet those needs, STEAM teachers should guide students in design thinking (empathize, define, imagine, prototype, and test) in practice. Therefore, it is clear that STEAM education is in line with the goals of civic education and can help students develop their critical thinking and problem-solving skills.

Community scientific projects in teaching and climate change - I

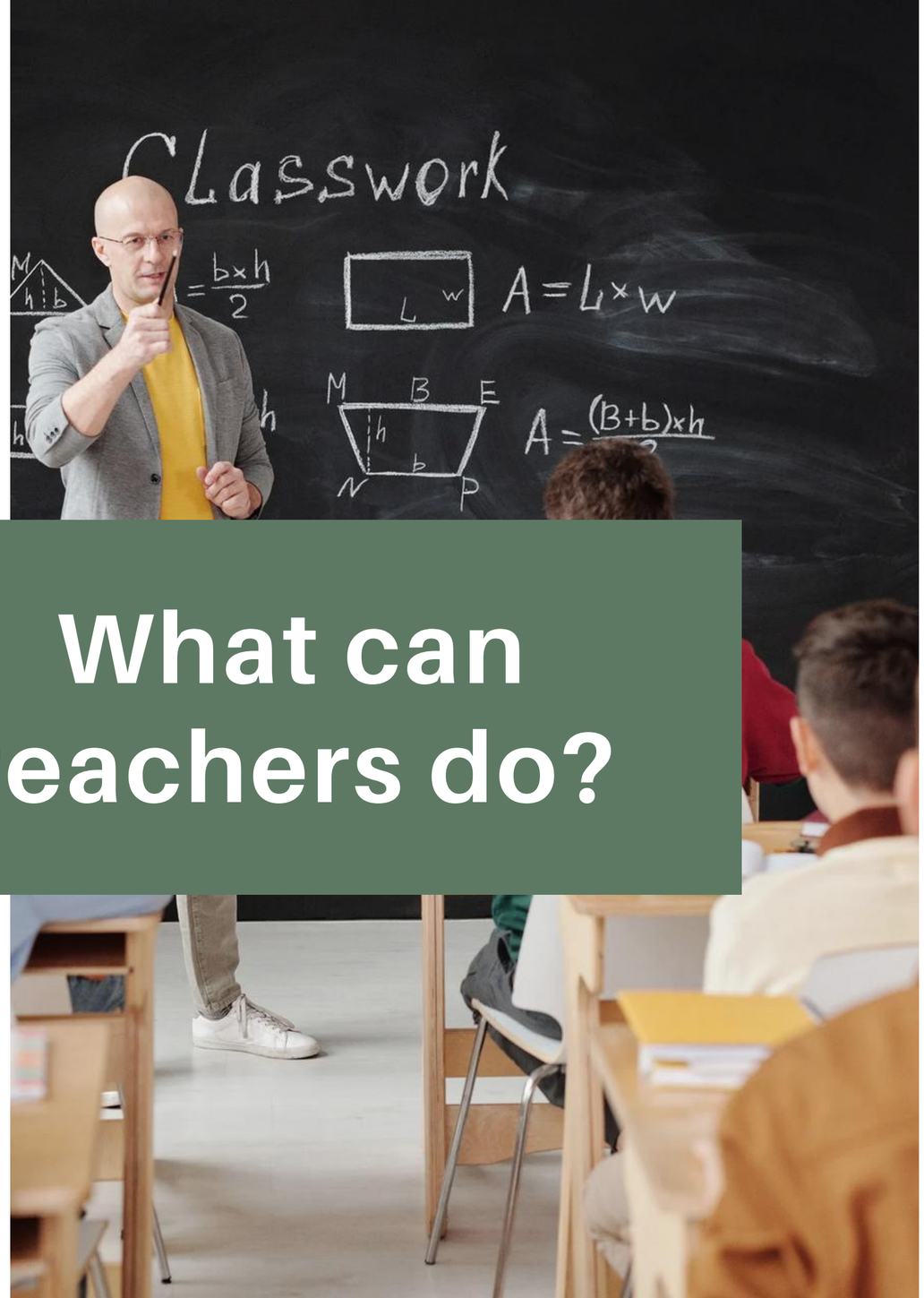
In line with the STEAM approach and at the same time thinking about climate change, engaging students in the fight against climate change and raising awareness about the topic, the best start for educators and STEAM professionals would be to implement community science projects with students in the classroom. Community science projects, while giving students the opportunity to identify issues in their communities and providing authenticity to the learning experience, can also help students materialize the things covered in the classroom, along with raising awareness of climate change in their environments.

Why are community science projects important?

Community science projects in schools are an important tool in teaching and addressing climate change for several reasons. First, they enable students to actively engage and contribute to scientific research that can help us better understand the impacts of climate change on our communities and environment. This hands-on approach to learning can be more effective than traditional classroom instruction and can help students develop critical thinking skills and scientific literacy.

Moreover, community science projects can help students develop a sense of ownership and responsibility for their local environment and community. By working on projects that address local environmental issues, students can see the direct impact of their efforts and develop a sense of agency and empowerment. Community science projects can help raise awareness of climate change and its impacts, promoting greater understanding and concern for this critical issue. Enabling students to work with members of their community to solve local environmental challenges promotes community engagement and collaboration.

Furthermore, community science projects can promote interdisciplinary learning by integrating the fields of science, technology, engineering, art, and mathematics (STEAM). This approach can help students develop a more holistic understanding of climate change and its impacts, as well as the different ways in which different fields can contribute to solving global challenges.
Community science projects require interdisciplinary collaboration between science, technology, engineering, art and mathematics, providing students with the opportunity to develop a wide range of skills and knowledge and expand their interdisciplinary skills to contribute to solutions to one of the most pressing problems of our time.



What can teachers do?

Teachers play an important role in promoting and implementing social science projects against climate change in schools. They are drivers of engagement by implementing STEAM projects in their lessons and curriculum. The role of teachers in promoting worthwhile projects that really support student success in learning and that can have a positive impact on the (local) community is not acceptable.

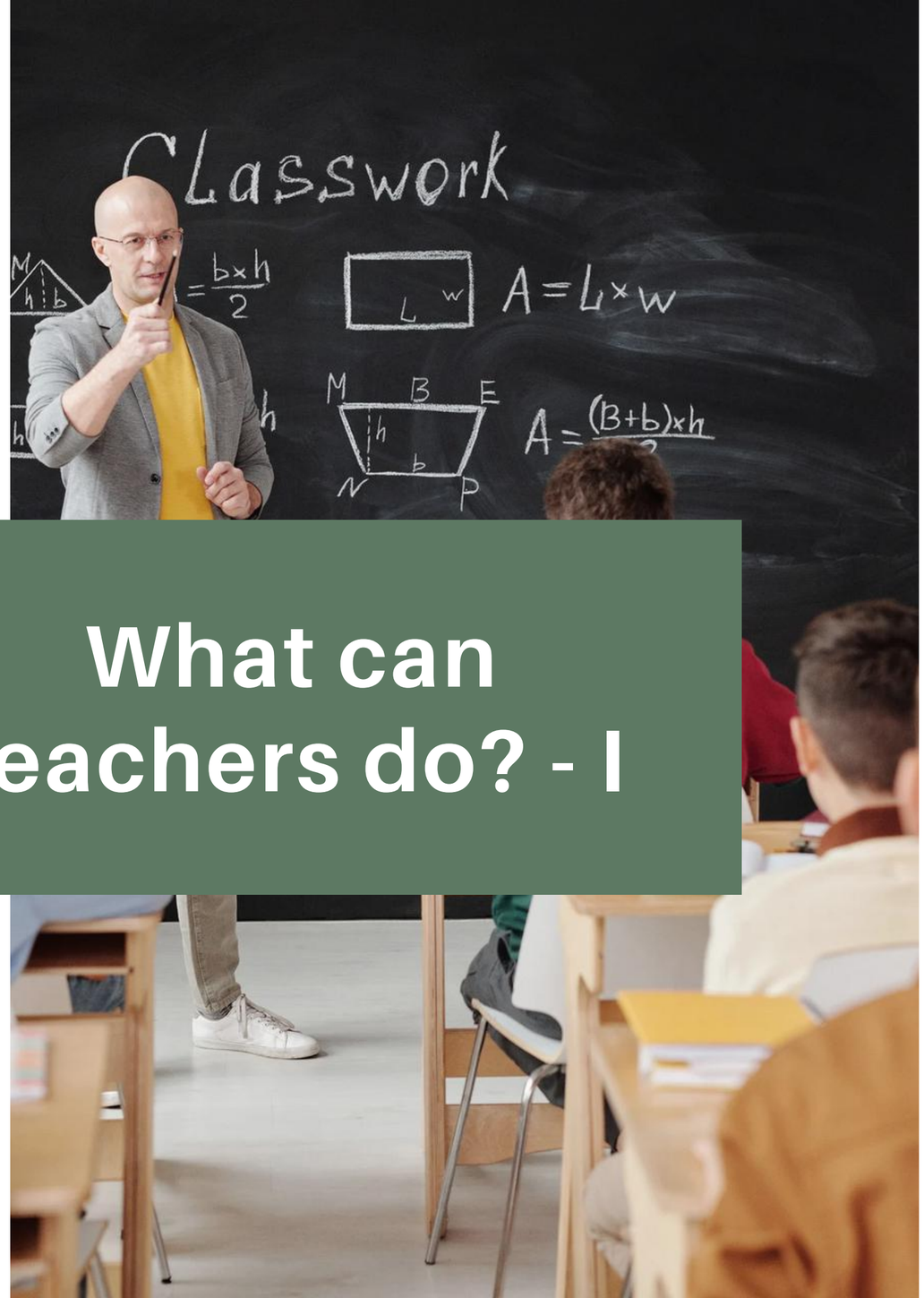
Identify local environmental challenges: Teachers can work with students to identify local environmental challenges related to climate change, such as air pollution, urban heat islands, or water scarcity.

Develop project ideas: Teachers can work with students to develop project ideas that address these environmental challenges, such as community gardens, renewable energy installations, or water conservation initiatives.

Partnering with community organizations: Teachers can partner with local community organizations, such as environmental groups, government agencies, such as a local garbage collection agency or city gardening agency, or innovative companies, to provide resources and support for community science projects.

Encourage interdisciplinary collaboration: Educators can encourage interdisciplinary collaboration between science, technology, engineering, art, and mathematics to provide opportunities for students to develop a wide range of skills and knowledge. For this, teachers could work together with their colleagues who teach different subjects to create a project that can be carried out interdisciplinary.

Emphasize creativity: Art can play a valuable role in developing community science projects. Encourage creativity and artistic expression in the project to help engage community members and inspire innovative solutions to environmental challenges



What can teachers do? - I

Facilitate project implementation: Teachers should provide guidance and support to students as they implement their community science projects, helping them to meet challenges and stay on track. They can do this by implementing a feedback mechanism and being present whenever questions arise.

Evaluate and monitor: Finally, it is important to evaluate and monitor the success of the project over time. Collect data on project impact and use this information to improve future community science projects.

Share project results: Teachers can share project results with the wider community, promoting awareness and engagement around climate change issues. Teachers could organize a community event for parents and friends where students present their project results.

By taking these steps, teachers can help students develop the skills and knowledge needed to address the environmental challenges associated with climate change, while promoting community engagement and interdisciplinary learning.

An example of an activity

The following section presents some broad themes for example activities and how they might be implemented in school, followed by a detailed elaboration of one example:

Air Quality Monitoring: Students can use low-cost sensors to monitor air quality in their community and collect data on air pollution levels. This project may involve interdisciplinary collaboration between science, engineering and technology. For this project, schools should invest in appropriate technology. This activity could provide valuable insight into how air pollution works. Sensors could be placed in different locations with different air quality (high traffic roads or in the woods) to teach students what causes poor air quality.

Sustainable Energy: Students can explore the use of renewable energy sources, such as solar or wind energy, and design and build small sustainable energy systems. This project may involve interdisciplinary collaboration between science, engineering and art. To do this, students could visit a company that makes solar panels or, on a smaller scale, make wheels in the classroom from materials such as wooden sticks and thick paper to demonstrate how wind can generate energy.

Water Conservation: Students can research water conservation techniques and develop plans to reduce water use in their community. This project may involve interdisciplinary collaboration between science, engineering and mathematics. Educating students about water conservation can include classroom instruction, school assemblies, and other educational activities. Teachers could set up a water-saving competition between classrooms, and the class that saves the most water in a certain period of time can win a prize.

Moreover, students could build a rainwater harvesting system to collect and store rainwater for later use. This water could then be used for a gardening project.

Example of activity - I

Climate Change Action: Students can develop educational materials and programs to raise awareness about climate change and its impacts on their community. This project may involve interdisciplinary collaboration between science, art and technology. For example, students could make protest signs to attend the climate strike. Another educational example could be visiting a local waste incinerator or public garden to learn more about community facilities.

Community Gardening: Students can work to build and maintain community gardens, using principles of biology, chemistry and ecology to create healthy and sustainable growing environments. This project may involve interdisciplinary collaboration between science, art and mathematics.
Given the space, students could make a school garden. This project teaches students about sustainable agriculture, environmental science and healthy eating.

To begin, students can research the different types of plants that grow well in their local climate and identify which would be suitable for a school garden. They can then work on designing the garden layout, creating a planting schedule and preparing the soil.

Students can also use technology to create a digital map of the garden, using tools such as Google Earth to map the area and identify potential challenges, such as areas with too much or too little sunlight. They can then use engineering principles to design and build structures for the garden, such as raised beds or trellises.

In addition to these STEAM-related activities, students can also engage in garden-related art projects. For example, they can create signs to indicate different types of plants, design artwork to decorate the garden, and use photographs to document the garden's progress over time.

Example of activity - II

Students can use math skills to calculate how much water and fertilizer the garden will need and to measure plant growth and yield. A rainwater harvesting system could be installed to collect water for watering plants.

As a reward, students can learn to enjoy the fruits of their labor by admiring the plants and flowers they have grown or even being able to pick fruit.

Creating a school garden is a hands-on, multidisciplinary project that engages students in STEAM learning while teaching them about environmental sustainability, healthy eating, and the importance of community involvement.

Example of activity: Community garden project for climate change

Goals:
- Increase students' awareness of the impact of climate change on their local environment,
- Encourage students' motivation to engage in sustainable practices in their communities.

Duration: one semester

Materials:
- Garden tools (shovels, trowels, gloves, etc.)
- Seeds or seedlings of autochthonous plants
- Compost
- Suitable land for gardening
- Equipment for research into local ecosystems and climate change
- Digital camera or smartphones for documentation

instructions:

1. Research and discussion (1-2 weeks):
- Divide the students into small groups.
- Assign groups with a specific aspect of climate change for research (e.g. impact on local communities, species migration, gas emissions, air pollution, etc.)
- Encourage students to gather information from reliable sources and present their findings to the class.
- Facilitate a class discussion or report on the local impacts of climate change and the importance of sustainable practices.

Example of activity: Community garden project for climate change - I

2. Engagement in the community (2-3 weeks):

- Together with the students, research relevant organizations, gardening clubs, municipal sections, contact them to discuss potential cooperation opportunities or get advice on suitable plants for the project.
- With the help of students, organize a community meeting at school to present the project idea to other students and also invite local people to participate or give their input.

3. Garden design (2-3 weeks):

- Communicate with your school, local NGOs, community members and relevant parties to secure suitable land for gardening.
- Let the students observe a part of the garden in their groups and design that part with indigenous plants, biodiversity and support for pollinators.
- Each group should also incorporate sustainable practices into their design, such as water conservation, composting or recycling materials for garden structures.
- Combine designs into one plan for a shared garden.

4. Planting and maintenance of the garden (4-6 weeks):
- Arrange specific days for students to prepare the soil, plant the seeds and maintain the garden.
- Have students document progress in the garden with photos, drawings and journal entries.

5. Reflection and presentation (1-2 weeks):
- Have students reflect on their experiences with the garden project and discuss, during the lesson, the things they have learned about community engagement and climate change.
- Organize an exhibition for students to present their work to the school, other students and the local community and share the garden's impact on the local environment, along with the importance of sustainable practices in the fight against climate change.

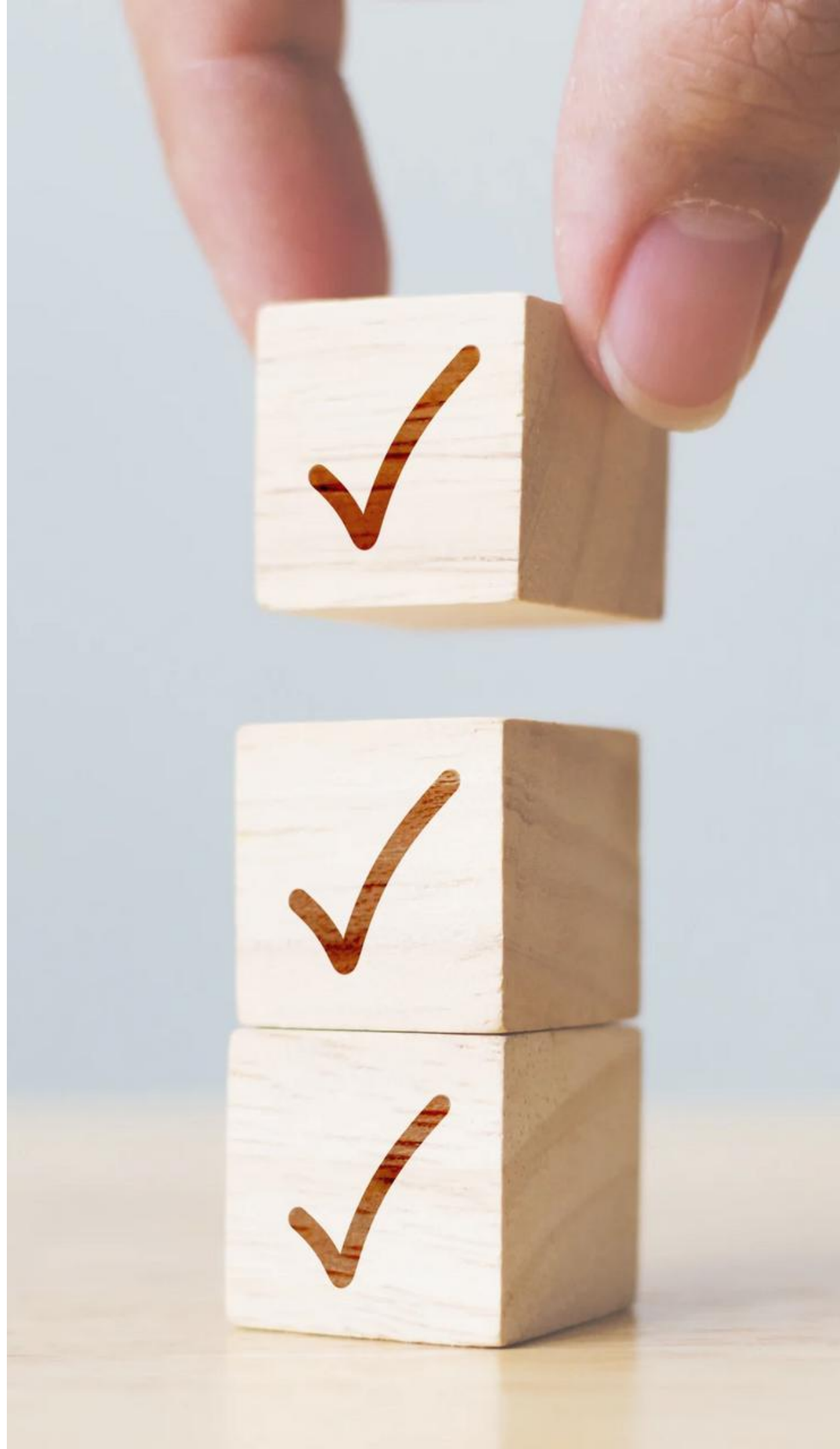
The above project will help teachers to support students with relevant skills and knowledge in understanding the impact of climate change on the local environment, taking initiative for the local community and active citizenship.

Concluding remarks

In conclusion, when implemented in an educational environment with a STEAM approach, community science projects can play a key role in raising environmental awareness, active citizenship, and interdisciplinary learning for students. These projects provide students with authentic environmental challenges, opportunities to work effectively together with their peers and the local community to develop critical thinking, leadership and problem-solving skills to combat climate change today and for the future.

Teachers are key stakeholders for the implementation and promotion of community science, STEAM education and environmental education projects in schools. By giving students support and supervision in identifying local environmental challenges, encouraging teamwork, and guiding students to effectively implement their project ideas, teachers can help students develop the skills and knowledge needed to become active citizens in the fight against climate change.

Finally, as the challenges of climate change grow across Europe and the world, it is of utmost importance that we equip the next generations with the necessary tools, skills and knowledge to create a sustainable and green future. Community science projects, integrated into the STEAM approach, with teachers trained and informed on how to implement them, will not only enrich students' learning experiences, but also empower students with responsibility and ownership of the planet, making our future a greener and more sustainable place.



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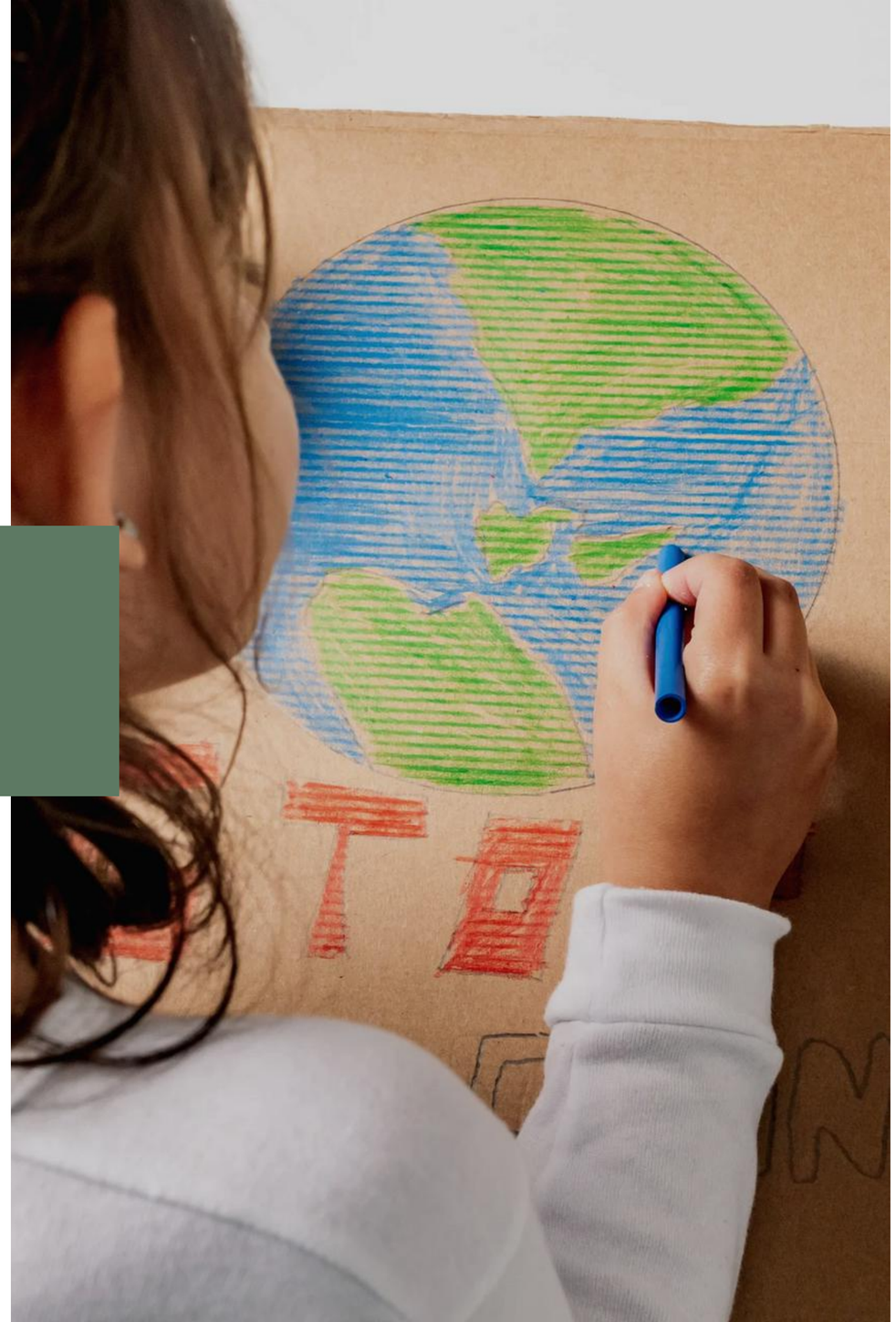

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