STEAM4CLIMATE curriculum

handbook for teachers

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STEAM4CLIMATE

STEAM Education to raise awareness about Climate Change challenges and prepare learners to become true agents of change

STEAM4CLIMATE curriculum: Handbook for teachers

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Declaration

This handbook has been prepared in the context of the STEAM4CLIMATE project. Where other published and unpublished source materials have been used, these have been acknowledged.

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- FOTA4Climate in Poland: https://fota4climate.org
- BERUFLICHES SCHULZENTRUM LEONBERG: https://www.bszleo.de/

Welcome note

Welcome to the STEAM4CLIMATE Handbook for teachers

Dear teachers,

Welcome to an exciting journey through the pressing issue of our time: climate change. This handbook is designed to empower you, as educators, to integrate climate change education within the STEAM framework, fostering a generation of informed, skilled, and passionate environmental stewards.

Inside, you will find a rich array of resources aimed at not only raising awareness about key challenges linked to climate change—such as energy production, sustainable housing, sustainable food, biodiversity and effects of high temperature in human body—but also at helping you implement these topics into your classrooms (with students 12-16 years old) in engaging and practical ways.

The handbook is structured in a manner to provide you with a comprehensive understanding of each challenge, followed by suggested activities and discussions that can help bring these issues to life for your students. The handbook includes videos and interviews with experts and activists, effectively connecting your classroom with the broader community of practice. The educational content therein has been designed to help you introduce the topics in the classroom, encourage critical thinking and inspire your students to become agents of change in their own communities.

While this handbook itself does not cover the implementation of student-led projects, it is structured to facilitate the transition to such hands-on activities, providing a pathway to explore these concepts thoughtfully. This setup prepares both you and your students for a seamless integration into more project-focused learning in future resources.

We hope you find this resource a valuable tool in your teaching, enabling you to effectively speak about and explore the science behind climate change in ways that resonate with and engage your students.

Together, let's prepare our students to take thoughtful and impactful action towards a sustainable future.

The STEAM4CLIMATE team

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Introduction

Overview of the STEAM4CLIMATE handbook and its purpose

This handbook has been developed as part of the STEAM4CLIMATE Erasmus+ project, specifically targeting secondary school teachers. It aims to equip educators with the tools and insights needed to effectively introduce five key climate change challenges into the classroom, utilizing STEAM pedagogy to familiarize students (12-16 years old) with the underpinning topics and influence their deeper engagement with these issues.

Chapter 1 provides an overview of the climate crisis, detailing its causes and current impacts. It sets the stage for further discussions and explorations within the classroom, establishing a foundational knowledge necessary for addressing the subsequent challenges.

Focusing on pedagogical practices, Chapter 2 discusses how STEAM education can significantly enhance climate change education. It offers practical ideas for integrating climate change topics into STEAM subjects and explores the benefits of combining project-based learning with STEAM approaches within the context of climate education. The pedagogical benefit of keeping the authentic context alive and as a basis for building educational experiences is also stressed.

Chapter 3 focuses on five significant challenges related to climate change: 1. Energy Production, 2. Sustainable Housing, 3. Biodiversity, 4. The effects of high temperatures in human body and 5. Sustainable food. These challenges were identified through extensive desk research by the STEAM4CLIMATE partnership and were selected in collaboration with participating schools and partners. The chosen topics were more in line with school curricula, making them practical for educational settings, but they also address critical aspects of climate change that are particularly relevant, needed and impactful. By focusing on these areas, the handbook aims to provide teachers with accessible, straightforward presentations complemented by practical activities, videos, and other resources. These materials are designed to help educators introduce these complex issues to students in a manner that encourages discussion, critical thinking, and reflection on potential solutions.

The handbook is designed to serve as a bridge, seamlessly transitioning from introducing the five challenges in the classroom to engaging students in hands-on projects. It facilitates a smooth progression from familiarizing students with the topics to actively involving them in practical projects centered on these challenges. This approach not only enhances students' understanding of underpinning STEAM- disciplines but also empowers them to communicate their ideas about climate change effectively. By connecting with a community of experts and activists, the initiative gains an authentic character, inspiring students and providing them opportunities to meet individuals who can help them make a meaningful difference in the future.

Chapter 1

The Climate Crisis:

Understanding Our Planet's Greatest Challenge

This chapter provides an overview of the climate crisis, detailing its causes and current impacts. The climate crisis represents the most significant threat our planet currently faces [1]. Recent climate-related events globally underscore the accelerating pace of change.

Let's uncover the extreme weather hitting STEAM4CLIMATE countries in the last 2 years

GREECE

In 2023, Greece experienced severe flooding in its central regions due to heavy rains that followed prolonged heatwaves and fires [2]. Storms Daniel and Elias battered central continental Greece, causing significant disruptions in daily life, substantial environmental damage, and challenges to the local agriculture and labor market [3] [4] (Figure 1).

Figure 1: Flooded area in central Greece after storms Daniel and Elias [4].

GERMANY

Same year, Germany experienced several extreme weather events intensified by climate change. One notable event was the severe storms that occurred on June 22, 2023, across various regions in Germany [5]. These storms, propelled by the "Lambert" low-pressure system, brought with them thunderstorms, giant hailstones, and heavy rains leading to flooding and significant property damage in areas such as Hessen and Rhineland-Palatinate. The storms were so severe that they disrupted transportation, with long-distance train services being halted and local transport affected in several cities [5]. In 2022 Germany also witnessed above-average fire danger throughout most of this year due to the hot and dry conditions, leading to heightened wildfire activity. This included an increase in carbon emissions from wildfires, with some regions experiencing their highest emissions in at least the last two decades [6].

FRANCE

In recent years, France has faced increasingly frequent and intense heatwaves, posing serious threats to public health, agriculture, and ecosystems. The summer of 2023 witnessed a particularly severe heatwave, with temperatures often exceeding 40 degrees Celsius (104 degrees Fahrenheit), breaking records and causing widespread concern. Cities like Paris endured extended periods of extreme heat, heightening health risks for vulnerable populations including the elderly and those with pre-existing conditions. Additionally, France has experienced altered precipitation patterns, resulting in more frequent droughts and intense rainfall. These changes significantly impact water availability and increase the risks of flooding and landslides, affecting lives and economic stability.

POLAND

If one notices that the average of -5 and +25 is 10, but the average of -15 and + 35 is also 10 it is clear that information about the rise of average temperatures alone is not sufficient to judge the consequences of this change. Spring of 2024 in Poland is a great but terrifying example of this phenomena, with extreme differences in daily temperatures [7]. The hottest February and March in history of measurements started prematurely the vegetation. The beginning of April brough also the highest temperatures ever observed in this month, but also brought a freezing cold in the end, with temperatures reaching -8 Celsius degree [7].

Figure 2: Fires set by Polish farmers to heat up canopies [8].

As a consequence, the farmers needed to start the desperate fight against cold destroying flowering crops. One method was to set a fire in the vineyards or orchards, so the warmth of smoke could heat up canopies (Figure 2).

A report [9] for the year 2023 shows that there are extreme conditions not in summer but also in winter. To put it simply: when it's hot, it's extremely hot, and when it's cold, it's extremely cold.

The combination of extreme temperatures and unpredictable rainfall is damaging crops, leading to reduced agricultural yields. The drought conditions, especially in the spring, coupled with intense summer rain, have created challenging conditions for Polish farmers, threatening food security and increasing economic instability in rural areas. The fluctuating rainfall patterns have resulted in both droughts and floods. June 2024 experienced extreme variability, with some regions facing heavy rainfall leading to flash floods, while others experienced drought-like conditions [10] (Figure 3).

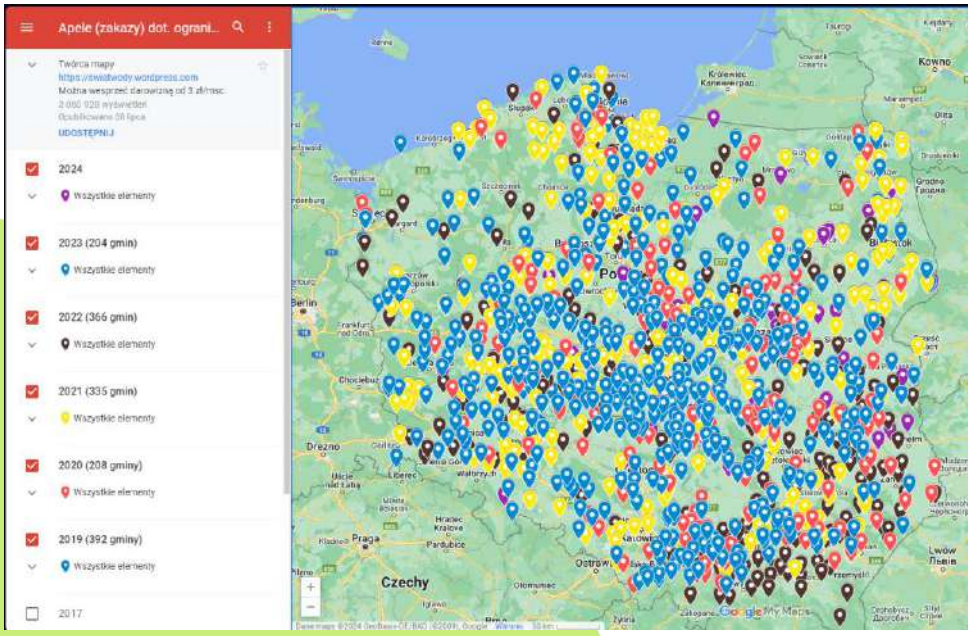
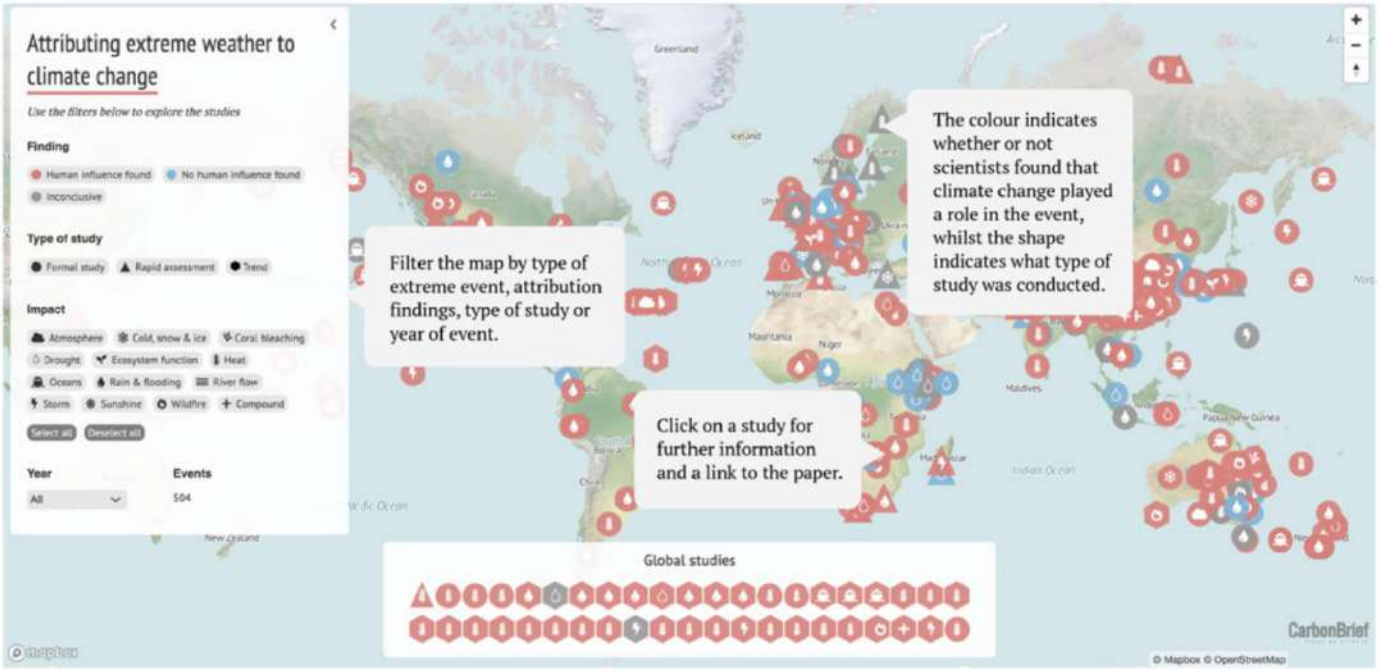


Figure 3: Map of Poland showing the variability of weather conditions in June 2024 [10].

Climate change is here and it is global

Similarly, other climatic events around the world serve as stark evidence of this rapid change [2]. Check the map (Figure 4) to see how climate change affects extreme weather around the world

Figure 4: Map of extreme weather conditions around the world [11].



The map illustrates 504 extreme weather events and trends worldwide that have undergone attribution studies by scientists. Various symbols on the map represent different types of extreme weather, such as heatwaves, floods, or droughts [11]. The colors on the map—red, blue, and grey—indicate whether the attribution study established a connection to human-induced climate change (red), found no link (blue), or yielded inconclusive results (grey).

What is climate crisis?

Climate crisis (or climate emergency) is a term coined in the last 5 years to emphasize the urgency and severity of the impacts of climate change [12].

However, unlike the term “emergency” which is usually defined as a situation that describes an immediate risk, crisis is a term that emphasizes how critical a situation is and the fact that something can be brought to a tipping point [12].

Therefore, the term climate crisis emphasizes how critical the situation of our planet is and the fact that the existing climate conditions and climate data show that we are close to a tipping point in terms of the viability of our planet.

The term “climate crisis” was first used by the states of the Pacific to raise awareness of the steady rise in sea levels, which is threatening the existence of many islands (Figure 5).

Figure 5: Under the slogan “We are not drowning, we are Fighting” people on islands in the Pacific Ocean *warn of the threat to the existence of many islands due to the steady rise in sea levels [11].*

What is climate change?

Climate change is used to describe long-term changes in temperature and weather [13]. Climate change is nothing new. For centuries, it has been caused by natural phenomena such as changes in solar activity or the eruption of large volcanoes [13]. However, over the last two centuries, humanity has been the main driving force. One of the main reasons is the burning of fossil fuels such as coal, oil and gas, which produce large amounts of greenhouse gas emissions, leading to a steady rise in temperatures due to the amount of heat from the sun trapped on the Earth [13] [14].

Warming is not the only consequence of climate change [11]. Extensive droughts, water shortages, intense fires, rising sea levels, floods, melting polar ice, catastrophic storms and declining biodiversity are among the major impacts of climate change [11]. Consequently, all these phenomena have a great impact on the quality of human life, including health, food production, housing, security and employment [13].

Greenhouse gasses (GHGs)

GHGs are gasses in the earth's atmosphere that trap heat [16]. These gasses consist of carbon dioxide (CO_2), methane, ozone, nitrous oxide, chlorofluorocarbons and water vapor.

If human-induced climate change persists at its current pace, the World Bank predicts up to 180 million climate refugees by 2050 [15]. Currently, one person is forced to leave his/her home every two seconds, adding to the over 70 million displaced globally. The DW documentary series 'Displaced' (Figure 7) explores the root causes of this crisis and examines the role of wealthy industrialized nations in the increasing migration from the Global South [15].

Figure 6: *Still from DW documentary 'Displaced' [15].*

Greenhouse gasses (GHGs) and Emission Impacts

To maintain a viable climate on Earth, global warming should not exceed 1.5°C by the end of the century [13]. However, if nothing is done immediately, it is estimated that global warming will be up to 3°C. To avoid such outcome, the GHGs emissions should be radically minimized. A short-term goal is to halve global emissions by 2030. This can be done by using renewable energy systems, such as solar and wind, and gradually phasing out fossil fuels [13].

Adapting to climate change

Adapting to the impacts of climate change is a critical and complementary strategy to reducing emissions. It encompasses a spectrum of actions tailored to mitigate the adverse effects of climate change on our communities and natural environments [13][17].

On a smaller scale, simple yet impactful actions can include planting native vegetation around homes to improve carbon capture and managing waste to keep our surroundings clean and less prone to disease vectors. On a larger scale, developing sustainable buildings that are not only energy-efficient but also capable of withstanding extreme weather conditions is essential. Furthermore, upgrading urban infrastructure to be more resilient can reduce the long-term costs and dangers associated with increasingly severe weather events. These are a few examples of adaptations that can help safeguard our communities, protect ecosystems, and ensure a sustainable future for upcoming generations.

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Chapter 2

The STEAM4CLIMATE pedagogical approaches

This chapter outlines the pedagogical approach to teaching climate change proposed in the context of the STEAM4CLIMATE project.

This approach seeks to raise awareness of climate change by addressing a number of key challenges and emphasizing 3 core pedagogical methodologies: STEAM pedagogy, Authentic learning with an emphasis on real-world contexts and Project-based learning.

Why climate change education?

A United Nations (UN) study [1] identifies education as a key aspect in addressing key climate change issues. In particular, it argues that climate change education can motivate learners to change their attitudes and behavior, and pave the way for informed decisions. However, UNESCO research [2] found that 47% of national curriculum frameworks from 100 countries make no reference to climate change. This finding is also reflected in local reports. For example, in Alberta (Canada's 4th most populous province), teachers have reported inadequate education on this topic [3]. And while 95% of primary and secondary school teachers believe it is important to teach about climate change, less than 30% feel prepared to do so. At the same time, a significant percentage of students (almost 70%) struggle at explaining what climate change is [4].

"We basically have three choices: mitigation, adaptation, or suffering. We're going to do some of each. The question is what the mix is going to be. The more mitigation we do, the less adaptation will be required and the less suffering there will be"

John Holdren, 2007 (president of the American Association for the Advancement of Science)

The problem of introducing climate change education

Based on recent studies [3], one of the reasons why climate change is not introduced in schools is due to the fear of causing distress and hopelessness in the students. Another reason teachers avoid introducing climate change and inspiring students to become agents of change is the fear that such actions may be misinterpreted as political [5]. However, ignoring climate change is not a viable solution. Although teaching about environmental change can be challenging, it can be made easier by implementing a range of strategies.

A climate change topic can be explored into two spaces [3] (Figure 1): the problem space and the solution space. A good strategy is for teachers to focus on the solution space and, in particular, to help students identify several concrete actions that can be taken, while promoting a sense of hope. Solution-based learning is also suggested [2] [3] as a promising strategy that can help students share a common language and understanding of climate change, thus “fostering hope through action”.

Note for Teachers/Educators

"Guide students through understanding and participating in effective solutions. This not only instills hope but also empowers students to be proactive agents of change in their communities. Together, through education and action, we can foster resilience against climate challenges and build a sustainable path forward."

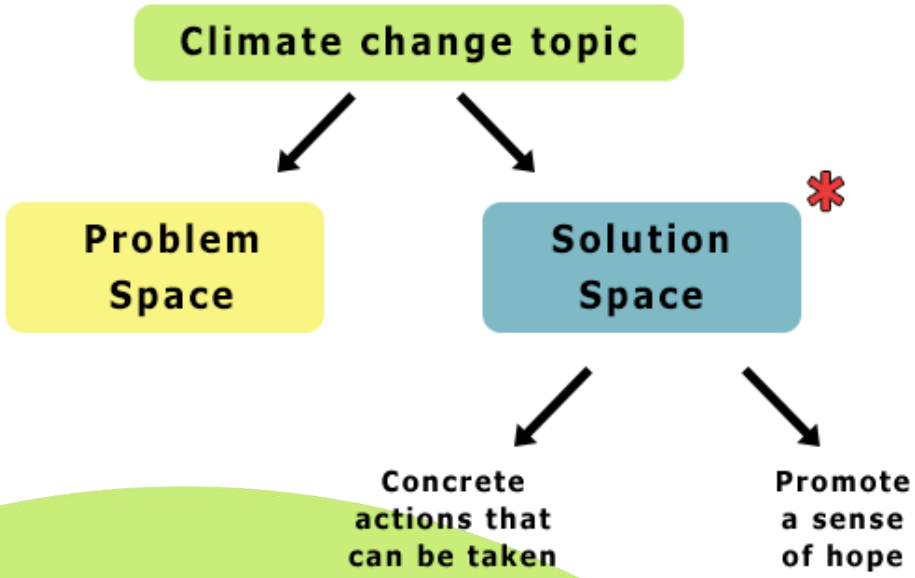


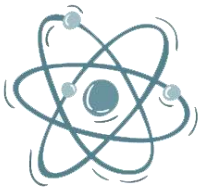
Figure 1: Graphical representation of exploring climate change topic

STEAM4CLIMATE pedagogical foundations:

STEAM pedagogy

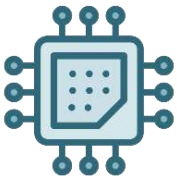
STEAM (Science, Technology, Engineering, Arts and Maths) education can offer a multifaceted approach to climate change education by empowering students to develop a comprehensive and cohesive understanding of climate science. STEAM education equips students with the knowledge, skills, and creativity needed to understand the complexity of climate change and to contribute to sustainable solutions. By bringing together different subject areas, thereby fostering interdisciplinary learning, STEAM education encourages students to think critically, innovate, and collaborate across disciplines, preparing them to tackle the challenges of climate change effectively [6].

Each component of STEAM education can contribute to address climate change



SCIENCE

Can help to understand the scientific principles behind climate change (e.g. greenhouse effect, carbon cycle, impact of human activities to the environment)



TECHNOLOGY

Can help to explore innovative technologies for renewable energy, monitor climate related parameter, propose sustainable solutions

ENGINEERING

Can help to design and build solutions for climate resilience, energy-efficient systems, and sustainable infrastructures

ARTS

Can be used as medium to communicate climate-related messages, raise awareness & inspire action through creative expressions

MATHEMATICS

Can be used to analyze climate data, model climate scenarios and understand the mathematical principles underlying climate science

However, STEAM education is not only a component-focused or subject-oriented approach, but a pedagogy that can also foster **interdisciplinary learning** and intersectoral efforts. Effective STE(A)M education should recognize its nature as an interdisciplinary practice that extends beyond the endeavors of any single teacher. It is essential to understand that STEAM teaching is not confined to one educator covering all subjects" [7].

Why STEAM?

By combining components and adopting a more holistic approach to climate change education, the educational benefits are maximized. Through the lens of climate change, students have an opportunity to engage with and explore scientific concepts, unraveling the intricacies of our planet's climate system, the role of human activity in altering this balance, and the numerous ways through which technology, engineering, science and mathematics can offer solutions. Conversely, for those students already alarmed by or interested in climate change, this pressing global issue can serve as a gateway to delve deeper into STEAM-related concepts. It prompts them to not only seek understanding and solutions within the realms of science, technology, engineering, arts, and mathematics but also to appreciate how these disciplines intertwine and bolster our collective response to environmental challenges. In essence, climate change education and STEAM education can dynamically reinforce each other, fostering a generation of informed, motivated, and innovative thinkers prepared to address the complexities of climate change [6].

STEAM4CLIMATE pedagogical foundations:

Authentic Learning

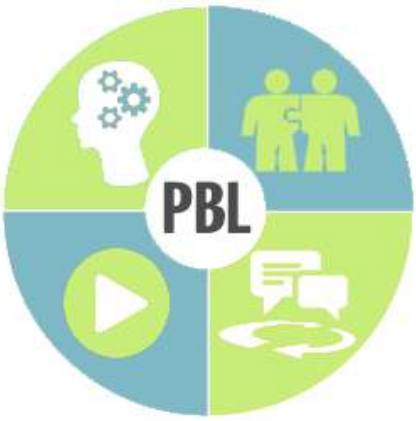
Authentic learning is a pedagogical approach that emphasizes real-world, relevant experiences as the core of the learning process. This approach seeks to engage learners in tasks that mirror the complexity and ambiguity of real life, encouraging them to apply their skills and knowledge in meaningful, practical ways. The "thick" view of authenticity goes beyond mere surface-level application of concepts in contrived scenarios. It involves deep engagement with genuine problems, interdisciplinary approaches, and collaboration with external communities [8]. This perspective not only aims to make learning more relevant and engaging but also seeks to cultivate critical thinking, problem-solving skills, and a sense of agency among learners [8].

Connecting authentic learning and its thick view of authenticity to climate education and STEAM involves integrating these subjects in ways that address the multifaceted challenges of climate change. For instance, students might engage in projects that require them to analyze local environmental data, propose sustainable solutions based on their findings, and communicate their ideas through digital media or public presentations. By working on real-world problems related to climate change, students can see the impact of their STEAM skills and knowledge in action, fostering a deeper understanding of the subject matter and its relevance to their lives and communities. This approach enhances students' learning experiences and prepares them to be informed, capable, and motivated participants in addressing global environmental challenges.

STEAM4CLIMATE pedagogical foundations:

Project-Based Learning

Project-based learning (PBL) offers a hands-on and experiential approach to education, allowing students to engage deeply with climate change issues and develop solutions [9]. Here is how PBL can contribute to raise climate change awareness and foster creativity in climate actions:



Real world relevance

Students have the opportunity to work on authentic, real-world climate-related projects

Critical thinking & problem solving

Students are engaged in identifying, analyzing & solving complex climate-related challenges

Creativity & Innovation

Students are encouraged to explore creative & innovative solutions to develop sustainable ideas

Collaboration & Communication

Students work together to address climate change issues

Environment & action

Students can actively contribute to climate actions initiatives, thus taking ownership of their learning and becoming agents of change

In PBL, students actively engage in acquiring and demonstrating new knowledge and skills by participating in a variety and/or a combination of hands-on activities, including [9]:

COLLECTIONS

Students gather and categorize items related to climate change, such as different types of recyclable materials, samples of plant species affected by climate change, or photographs documenting environmental changes over time.

PORTFOLIOS

These serve as evidence of students' mastery in understanding climate change, showcasing projects like research on carbon footprints, experiments on renewable energy, or reports on local environmental policies.

DESIGNS

Students create technological designs or prototype solutions aimed at exploring climate change topics, such as a solar-powered water purifier, a model of a sustainable city and more.

RESEARCH PROJECTS

Through designing studies, accessing information and communicating their findings, students explore topics like the impact of deforestation on global warming, the role of oceans in climate regulation, or the effectiveness of different renewable energy sources.

PLANS OR PROPOSALS

Students apply logical thinking, research, and time management to develop practical plans, such as a community initiative to reduce plastic waste in a specific region, a proposal for a school-wide composting program, a detailed plan for a sustainable garden and more.

SIMULATIONS

By participating in controlled or virtual experiences that mimic real-world scenarios, such as a simulated environmental disaster response, or city planning for rising sea levels, students gain insights into the complexities of climate change decision-making.

EXCAVATIONS

Students engage in discovering artifacts or evidence related to historical climate events, such as ice core samples that reveal past climate conditions or fossils that show the impact of past climate changes on biodiversity.

CONSTRUCTION

This involves the physical execution of designs related to climate change, such as building a rainwater harvesting system, creating a school garden with native plants, or constructing a model of a wind turbine.

SERVICE

Students develop and apply their skills by serving others through climate-related initiatives, such as organizing a community cleanup event, starting a recycling program at school, or educating younger students about energy conservation.

AUDITS

Students collect and evaluate primary data related to climate change, such as conducting an energy audit for their school to identify areas for reducing carbon emissions, assessing the biodiversity in a local park, or measuring the school's water usage to propose conservation strategies.

By integrating the strengths of **STEAM education** with **PBL**, students can achieve a comprehension of climate change, aqcuire essential skills, and participate in innovative problem-solving to tackle this global issue. This approach promotes multi-disciplinary teaching that focuses on cultivating students' general, transferable, and critical skills and competencies. Furthermore, PBL serves as an exceptional tool for **an in-depth, multifaceted, and comprehensive exploration of topics** from various viewpoints and through diverse learning methods. It empowers students to engage with the subject matter and challenge it from multiple perspectives and angles.

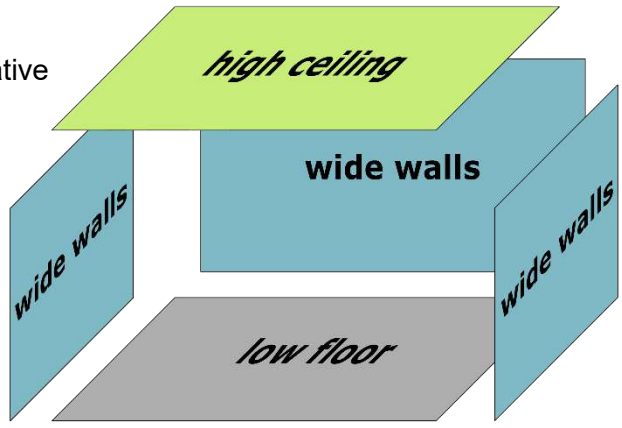
How to design a STEAM project to build engagement?

The "Low Floor, High Ceiling, Wide Walls" approach, as conceptualized by Seymour Papert and updated by Mitchel Resnick et al. [10], emphasizes creating learning environments where beginners can easily get started (low floor), experienced learners can pursue more advanced projects (high ceiling), and learners of all levels have multiple pathways to explore a wide array of ideas and interests (wide walls). This approach is grounded in the constructionist theory of learning, which suggests that learners construct knowledge most effectively through making things and reflecting on their experiences [11].

The aim is to cater to diverse learners, allowing them to engage at their own pace and level of expertise while fostering creativity, problem-solving, and a deep understanding of the subject matter. This approach has been introduced widely in robotics education but it also has educational potential and brings added value in the realization of STEAM related projects (digitally implemented or hands-on) facilitating all needs and learning styles.

In general, the whole idea is reflected in the following three questions:

- Low floors: Is it easy to get started?
- High ceilings: Does it scale with use?
- Wide walls: Is it flexible to meet different creative needs?



Low Floor, High Ceiling, Wide Walls in practice

An example of this approach in action can be seen in climate change education through a project focused on creating sustainable energy solutions. A beginner might start with a simple task, such as designing a basic solar-powered model (low floor) that demonstrates how solar panels convert sunlight into electricity. As learners gain confidence and skills, they could advance to developing more complex systems, such as a “smart” construction that integrates solar, wind, and hydroelectric power sources (high ceiling). The project offers a wide range of exploration, from experimenting with different energy sources and their efficiencies to applying their models to real-world scenarios like powering a small community or school, and/or developing an understanding of the broader picture (wide walls).

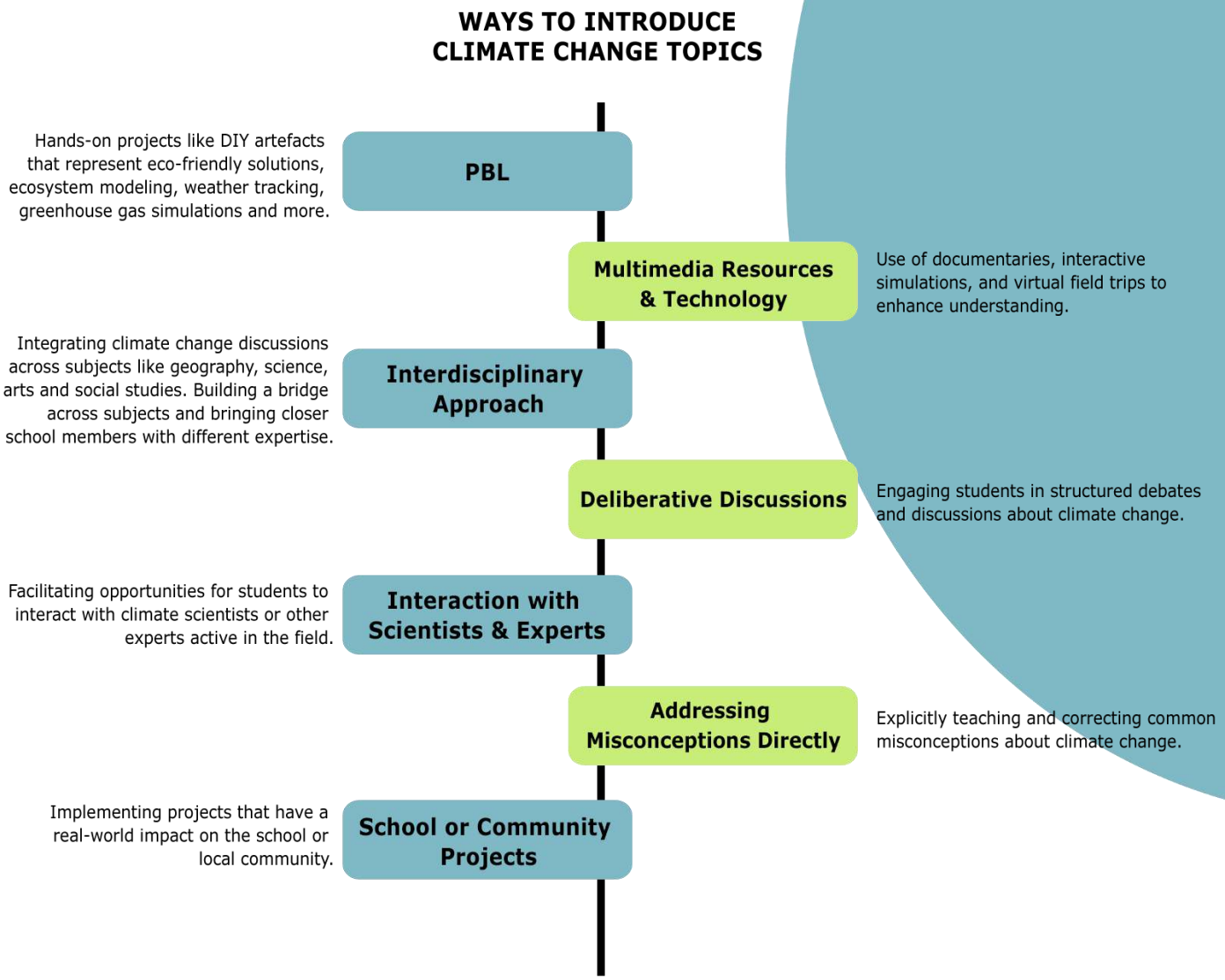
Notably, the project can also include community engagement, opening up to society and allowing students to reflect on their work. This reflection can help them understand how their efforts can be communicated and initiate dialogue and discussions that embrace different perspectives (another representation of wide walls).

Introducing Climate Change topics in the classroom

Introducing climate change topics in the classroom is increasingly important as interest in climate change education grows. Yet, it is accompanied by challenges such as misconceptions and the complexity of the topic. To address these challenges, it is essential to adopt active, student-centered teaching methods that make the information personally relevant and meaningful. One feasible way is through PBL as described above, where students engage in hands-on activities [9] such as creating models of ecosystems, tracking local weather patterns, or simulating the effects of greenhouse gasses.

Climate change education can be also supported through the use of multimedia resources and technology. Teachers can utilize documentaries, interactive simulations, and virtual field trips to provide students with a comprehensive understanding of climate change. For instance, students can watch the DW documentary ‘Displaced’ (see Chapter 1) to understand how climate change turns whole communities into climate change immigrants forcing them to leave their homes and move to other places with milder weather conditions. They can also use simulations to see how different variables affect global temperatures or how different parameters relate to one another.

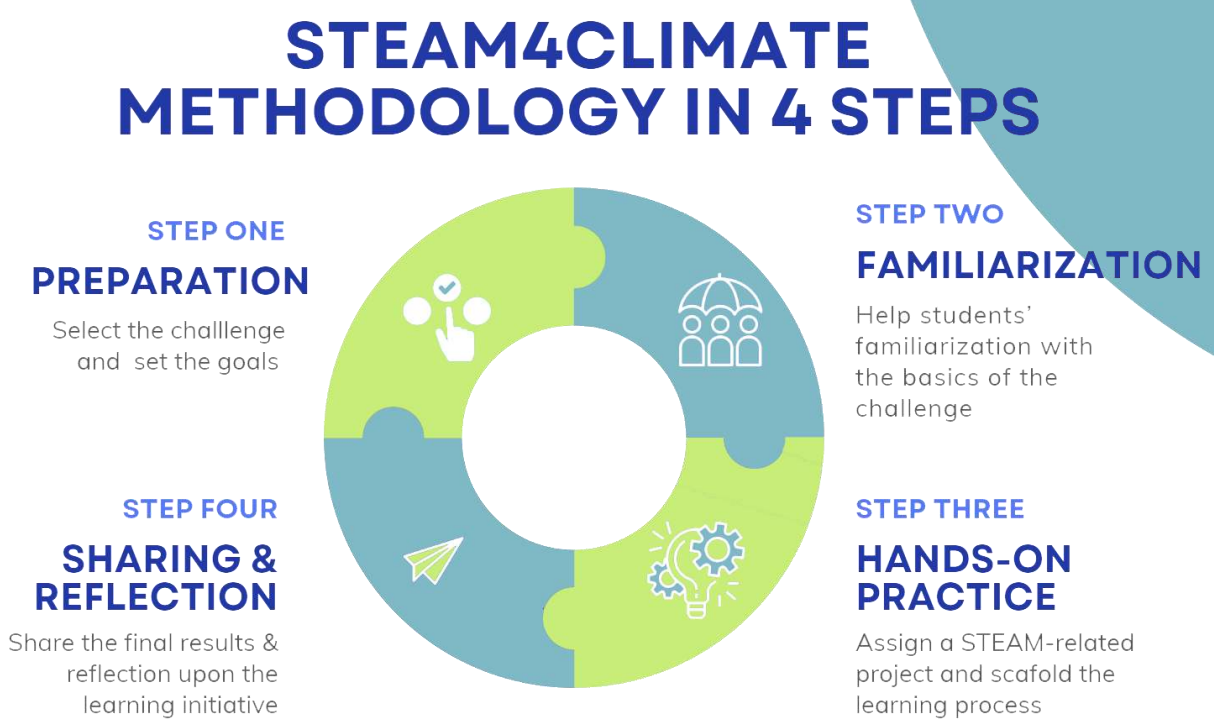
This way students are supported to visualize abstract concepts, making them more tangible and memorable. Integrating climate change discussions across various subjects, such as geography, science, arts and social studies, ensures that students gain a multidisciplinary perspective on the issue. Additionally, engaging students in deliberative discussions, facilitating interaction with scientists and experts, directly addressing misconceptions, and implementing school or community projects further enriches the learning experience [3] [12] [13].



These ways can be creatively combined with one another towards enriching students' learning experiences. Towards this end, this handbook provides teachers with ideas on how these approaches can be brought together facilitating the learning process and students' understanding on key challenges related to climate change.

The STEAM4CLIMATE Methodology

The STEAM4CLIMATE methodology is designed to immerse students in the critical issues of climate change through 5 key environmental challenges leveraging the interdisciplinary nature of STEAM. Through a structured series of stages, students are guided from initial challenge selection to hands-on project execution and reflective sharing, ensuring a holistic educational experience.



The STEAM4CLIMATE methodology follows 4 stages; the one step leads to the other but the steps have been designed in a way to allow repetitions (if needed) and the lessons learnt inform and update new educational cycles.

PREPARATION

1. Challenge selection: The teachers select carefully one challenge and sets the teaching goals taking into account the classroom dynamics, students' skills and interests.

2. Selecting methods and resources: The teachers plan how to introduce the challenge in the class by reviewing the introductory STEAM4 CLIMATE activities and resources.

FAMILIARIZATION

3. The teachers set up the working groups and facilitate in practice the exploration of key concepts related to the selected challenge, promoting collaborative learning and critical thinking. The aim of this step is students to become familiar with key aspects related to the challenge in an engaging way (i.e. through an experiment, a talk with an expert, a video that calls for reflection, brainstorming sessions and more)

HANDS-ON PRACTICE/ PROJECT WORK

4. This step revolves around the assignment of a hands-on project where STEAM disciplines serve climate change awareness. Each group is allocated with a specific project related to the selected environmental challenge.

5. The groups following the PBL approach work on their projects while the teacher(s) act as facilitators.

6. Establishment of checkpoints: Regular checkpoints are set to monitor progress and provide guidance, ensuring projects stay on track

SHARING & REFLECTION

7. Students' final projects or project results are brought into public with the support of the teacher(s). An event is organized for students to present their projects and their own narrative around climate change, fostering a culture of sharing and peer learning.

8. Students' feedback and experiences are collected enabling continuous improvement of the STEAM4CLIMATE learning intervention and experience.

The STEAM4CLIMATE approach invites teachers to act as guides on the side, facilitating the learning process by ensuring that the project has a clear temporal structure, with important milestones and deadlines being met.

Teachers are also encouraged to create connections between different subject areas, address climate change topics from multiple perspectives, and build relevant collaborative networks among fellow teachers and experts in the field.

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Chapter 3

The 5 Climate Crisis Key Challenges and how to introduce them in the class

This chapter presents the five key climate crisis challenges that the STEAM4Climate handbook focuses on to introduce climate change.

These are:

1. Energy production
2. Sustainable Housing
3. Biodiversity
4. Effects of High Temperature on the Human Body
5. Sustainable Food

Notation

As you move through the handbook, you will come across the following icons (usually in the upper right corner). Each icon indicates a dominant subject area in the activities or highlights a core practice being emphasized.

 Engineering

 Arts

 Technology

 Science/Physics & Chemistry

 Maths

 Social Science

 Implementation Scenario

 Science/Biology

 Tips and ideas

 Glossary

 Classroom Discussion / Talk with experts

NOTE FOR THE TEACHERS

For each challenge, the handbook provides a detailed description that introduces the topic and identifies several key concepts. These descriptions include references to literature and current research, ensuring that the content is scientifically valid and based on real-world facts. Additionally, each section highlights methods to mitigate the challenge, paving the way for possible solutions. This approach helps teachers gain a comprehensive understanding of the critical aspects of each challenge, building their confidence to introduce these topics to their students in an optimistic and hopeful manner.

Then, each challenge includes learning objectives, a proposed methodology, and a series of activities that address different aspects of the challenge through the lens of various STEAM disciplines. These activities are designed to facilitate discussion among students, encourage the exchange of ideas, and suggest ways to incorporate a hands-on approach to learning. To facilitate their implementation, each activity is enriched with diverse resources, such as images, graphics, videos, and expert interviews recorded specifically for the handbook.

Teachers can select from the activities based on their classroom needs, time constraints, available support, and students' interests, allowing for flexible and effective integration of climate education into their teaching.

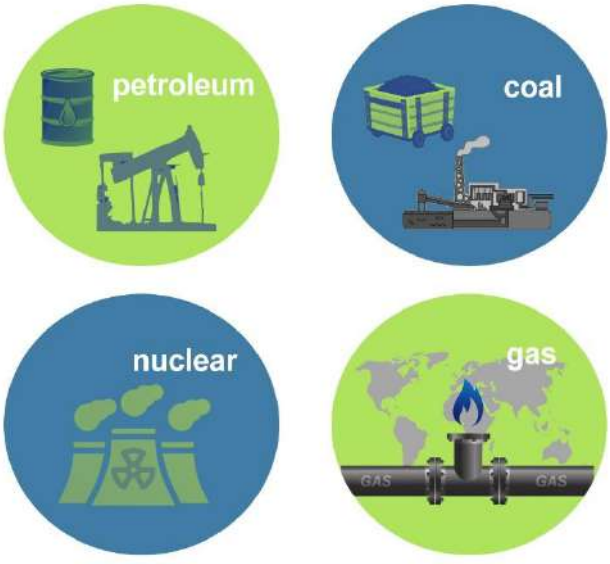
To provide further inspiration, the handbook includes implementation examples that present some of the proposed activities in hypothetical but realistic classroom scenarios.

Each challenge is linked with a STEAM project, which seeks to provide students with an all-encompassing and integrated learning experience. Students will get a thorough understanding of climate change and its challenges by mixing collaborative work, data analysis, computational thinking, and hands-on design and prototyping, thus providing sustainable solutions with a positive impact on their communities.

Energy Production

DESCRIPTION

Energy is used extensively in various sectors such as industry, transport, housing, agriculture and forestry. At a global level, energy is mostly produced by burning of fossil fuels such as coal, oil and gas, which produce large amounts of greenhouse gas emissions, leading to a steady rise in temperatures due to the amount of heat from the sun trapped on the Earth (i.e the greenhouse effect). In 2022, energy production accounted for 87% of global greenhouse gas emissions [1]. In the same year, 61.2% of electricity production came from burning fossil fuels, 29.6% from renewable sources and 9.2% from nuclear sources [2].



Non-renewable sources of energy

To keep global warming below 2°C, and steadily limit it to 1.5°C, radical changes in energy systems are needed over the next 30 years, including reducing fossil fuel consumption, increasing production from low- and zero-carbon energy sources, and increasing the use of electricity and alternative energy carriers [3]. Climate change can only be halted if greenhouse gas concentrations are stabilized [1]. It is therefore essential to find ways to reduce the production of energy from fossil fuels and to start massively using alternative energy sources that will bring emissions down towards net-zero. These alternative energy sources should also be affordable for all countries, since another part of the energy problem is energy poverty, which forces many people around the world to use materials (e.g. wood) that are harmful to themselves and the planet, in order to meet basic daily needs (cooking, heating etc.) [1]. Findings such as those presented by the United Nations for the period of 2015 to 2019 [3] which record a significant increase in the capacity and production of global wind, solar PV (photovoltaic) and hydroelectric power, which (combined with other low- and zero- carbon power generation technologies, including nuclear and modern biofuel sources [4]) have led to a total of 37% of global electricity production, are very encouraging in terms of a global shift towards more environmentally friendly and renewable energy sources. However, we are at a tipping point where this shift needs to happen massively, especially by countries with huge emissions.

DESCRIPTION

As mentioned above, such alternative and 100% renewable energy sources are wind power, solar power, hydroelectric power, bioenergy, geothermal energy, tidal power and ocean power [3]. Solar energy for instance can be harnessed through technologies such as solar panels and photovoltaics, and used in a direct or indirect way to meet everyday needs, from heating the water to generating electricity [5]. Wind energy can be harnessed through wind turbines and wind farms to produce electricity [6]. Such energy sources, which are renewable and widely available, are being considered as alternatives not only for electricity but for all energy systems, raising a number of challenges including technological, regulatory, market and operational challenges.

Renewable sources of energy

From a technical point of view and under certain conditions, current research, simulations and market scenarios show that it is feasible to switch to renewable energy sources for 75% of electricity production, and especially to wind and solar power [3]. For all energy systems many parameters need to be taken into account.

Wind and solar energy are very promising energy sources and probably the most efficient solution for mitigating and confronting the energy production challenge, but much research is still needed to successfully use them for massive energy production due to their unique characteristics, which are highly dependent on spatial and temporal variables that can lead to uncertainties in the short and/or long term [3]. Energy storage is another critical parameter for net-zero energy systems and needs to be carefully studied for producing efficient energy systems. Finally, it is also important to consider the surroundings of areas where renewable energy infrastructures (e.g. large-scale solar PV, wind farms etc.) are placed as this may have an impact on the local climate [3].

Measuring energy [7] : The energy we use in our daily lives is the results of processes occurring across the energy chain. The energy chain can be roughly divided into four stages: primary, secondary, final and useful energy. Primary energy is the energy available in primary resources (e.g fuels, gas, oil etc.). Secondary energy is the energy produced when primary energy is converted into a transportable form (e.g. liquid fuels, electricity etc.). Final energy is the energy purchased and received by a consumer (e.g. domestic electricity, petrol etc.). Useful energy is the energy used to produce the desired output (e.g the light produced by a light bulb, the kinetic energy of a car etc.). Between each of these stages there are significant losses that affect the efficiency of an energy system. Even a light bulb has losses by also producing heat. It is roughly estimated that the losses between the primary and the useful energy produced by fossil fuels can be between 64% and 75%. Reducing these losses by identifying and improving inefficiencies is also an important step in mitigating the energy challenge.

LEARNING OBJECTIVES

In this section students will learn:

1. Basic sources of energy
2. What low-carbon and net-zero energy sources are
3. What energy chain is
4. What is the impact of energy production on greenhouse gas emissions
5. Why it is important to shift to renewable sources of energy
6. Why it is important to identify and improve inefficiencies in energy systems

They will also be able to:

1. Identify different forms of energy (nonrenewable, renewable, low carbon etc.)
2. explain how energy production affects the concentration of carbon emissions
3. Identify different stages of energy chain
4. Propose solutions to mitigate the energy production problem

Interdisciplinary focus

Science

Engineering

Technology

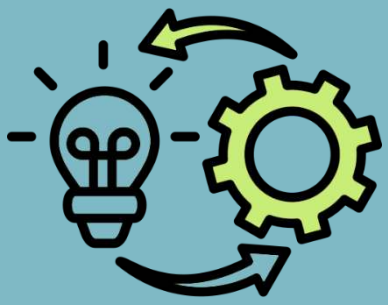
Arts

METHODOLOGY

Methods for introducing this topic in class:

- brainstorming
- running experiments
- representation of information through sketches or engaging presentations
- talk with experts

IMPLEMENTATION SCENARIO



Maria is a middle school ICT teacher and is about to introduce her students to the key challenge of Energy production. To engage her students in the learning process and inspire them to act as agents of change,

Maria is thinking of starting with a brainstorming session. She divides her students into teams of 3 or 4, and encourages them to search the internet and identify energy sources currently used in industry. Then she asks them to imagine how these sources could be reduced or reused, or how they can be substituted by alternative sources of energy such as solar power and wind. In this way, she will introduce her students to the key challenge of Energy production, while paving the way for raising discussions on how students can act to mitigate this phenomenon (e.g. researching turbine windmills and thinking about how they could build one to use the collected energy for the needs of their school or their community.

To help them better understand some scientific concepts behind this challenge, she is also inviting the Physics teacher to run some experiments. In this way, she is also hoping that will inspire some students to reproduce these concepts in a more artistic or technological way (e.g., create an interactive project in Scratch).

PROPOSED ACTIVITIES

ACTIVITY 1:

Raise discussion on available energy sources and their use on energy production

The aim of this activity is to familiarize your students, through brainstorming and discussion, with the available energy sources that are currently used to produce energy. Ask your students to do short research by sharing some of the following links, or show them some of the suggested videos to start a dialogue about the different energy sources, how they are found in nature and how they are used to produce energy. Through this activity, students will be able to identify the advantages and disadvantages of each energy source and realize why it is important to make a global shift to renewable energy sources. They will also become familiar with the terms low- carbon and net-zero sources

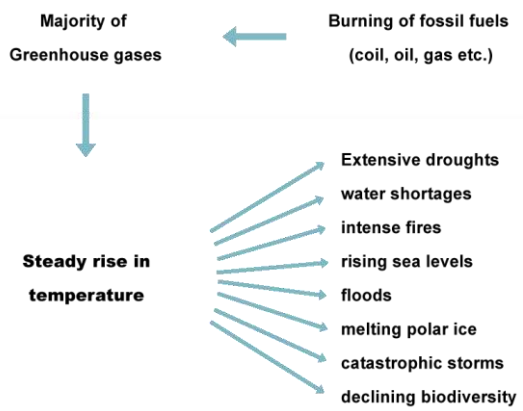


Figure 1: Example of a diagram showing the consequences of burning fossil fuels

Possible questions to initiate the dialogue:

- What are the main sources of energy?
- What are the main fossil fuels used to produce energy?
- Are there any other energy sources used for energy production
- What are low-carbon and net-zero sources? Can you name some?
- Why is it important to switch from fossil fuels to renewable energy?

Links to videos and material for initiating the dialogue:

- Fossil fuels: https://education.nationalgeographic.org/resource/fossil-fuels/
- Fossil fuels: https://www.youtube.com/watch?v=zaXBVYr9Ij0
- Nonrenewable energy: https://education.nationalgeographic.org/resource/non-renewable-energy/
- Renewable energy sources: https://www.youtube.com/watch?v=Giek094C_I4
- What is wind energy: https://www.youtube.com/watch?v=_8DtGAp1fyI
- Wind energy: https://www.youtube.com/watch?v=Z5c50-_hcD0
- Solar energy: https://www.youtube.com/watch?v=yFwGpiCs3ss
- Hydropower: https://www.youtube.com/watch?v=q8HmRLCgDAI
- Tidal power: https://www.youtube.com/watch?v=VkTRcTyDSyk

ACTIVITY 2:

Energy production and its impact on the environment and the climate - Recreating Greenhouse Effect

The aim of this activity is to familiarize students with the environmental impact of current energy sources and how their use affects climate. This activity can be developed around a discussion as well as an experiment in which you and your students will recreate the greenhouse effect, making this concept a visual and tangible experience. If you are not a physics teacher, you can consider inviting the Physics teachers to help with the process and emphasize some key scientific concepts. During the experiment, you can encourage your students to record temperature changes and discuss how higher temperatures affect climate change. You can also use this experience to discuss how current energy sources, and in particular the carbon emissions from burning fossil fuels, contribute to the greenhouse effect and increase the amount of heat trapped, leading to the need to switch to low-carbon or net-zero energy sources

Figure 2: Still from the video "Greenhouse effect explained in 2 minutes"

Possible questions to initiate the dialogue:

- How burning fossil fuels affect the concentration of CO2?
- How the concentration of CO2 affects climate change?
- What is the greenhouse effect and why is it important to reduce carbon emissions?

Links to videos and material that can help with the activity and the experiment:

- What is the greenhouse effect", https://www.youtube.com/watch?v=SN5-DnOHQmE
- Simulator presenting CO2 concentration over time, https://climate.nasa.gov/interactives/climate-time-machine#
- Fossil fuels and CO2 (need to sign up), https://ourclimateourfuture.org/video/chapter-3/
- "Greenhouse effect" simulator: https://phet.colorado.edu/en/simulations/greenhouse-effect/about
- "What causes air pollution", https://climatekids.nasa.gov/air-pollution/
- Greenhouse effect explained in 2 minutes: https://www.youtube.com/watch?v=VYMjSule0Bw

ACTIVITY 2 - EXPERIMENT:

Materials for recreating the greenhouse effect:

Two identical transparent containers, baking soda/powder, vinegar, cling foil, an infrared lamp and two digital thermometers

Greenhouse effect - experiment description:

The aim of this experiment is to recreate the greenhouse effect and help students understand how the high concentration of CO_2 in the atmosphere affects the constant rise in the temperature of the Earth.

1. Fill one container with air and the other with CO_2.

2. To produce CO_2, mix the baking soda and vinegar in the one container. CO_2 will immediately form.

3. Place a digital thermometer inside both containers and cover them with cling film.

4. Then, point the infrared lamp at the two containers and observe the temperature measured by the two digital thermometers.

5. The temperature in the container filled with CO_2 will rise quite quickly, demonstrating the 'global warming' effect of CO_2.

Figure 3: Image demonstrating the experiment

ACTIVITY 3:

Reducing the energy use/waste

In this activity students will reflect on the inefficiency of energy systems and the amount of energy wasted on a daily basis. Show to your students the 1st part of the "Interview with an Electrical Engineer" (link 1). Then, share with them the link to the Google Oneness project (link 2) and ask them to click on the energy activity to interact with the simulator for 20 minutes. By interacting with the simulator, students will realize how appliances in the household energy system can use energy even when they are not in use and how they can reduce this phenomenon by doing simple things, such as unplugging some electrical appliances when they are not in use or turning off lights when leaving a room.

The simulator starts by asking users to specify the number of rooms in their house (if they wish). Then they have to answer some questions such as "How many hours a day do you typically keep lights on in your house?" or do some actions like, unplugging a number of appliances. Based on their input (e.g. hours and type of light bulb, type of unplugged appliance) they are told how this energy use is interpreted in terms of CO2 emissions. In this way, they become aware of the amount of energy that can be saved on a daily basis, and therefore the carbon emissions that can be avoided, simply by changing a few habits.

When they have finished interacting with the simulator, encourage your students to share their thoughts about energy waste, and actions that can be taken to reduce it.

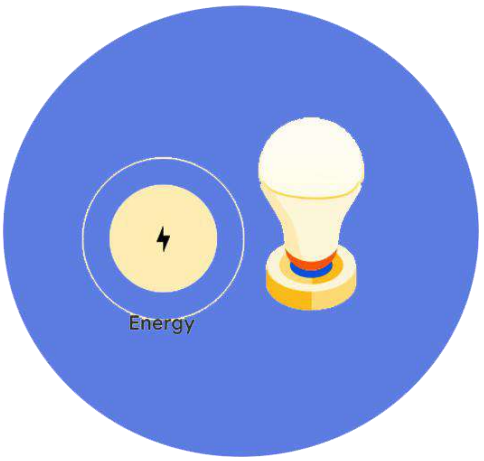


Figure 4:

Energy activity icon

Possible questions to initiate the dialogue:

- How many appliances are you using on a daily basis?
- Are you aware of the energy consumption of the electrical appliances you have in your home?
- Did you know that an electrical appliance can use energy even when you are not using it? What can you do to reduce this energy waste?

Links to videos and material that can help with the activity and the experiment:

- "Electricity - sources and uses", https://www.youtube.com/watch?v=ja8U4bFhEGQ
- Google Openness project: https://yourplanyourplanet.sustainability.google/
- Interview with an electrical engineer: https://youtu.be/BXbnoqWBeBs

ACTIVITY 4:

Where does the electricity come from and how can it be measured?

The aim of this activity is to familiarize students with the source of electricity and the ways that can be measured. Starting with a light bulb in a room, ask your students to make sketches/ diagrams of the electrical grid to trace the source of electricity as far back as they can imagine. Through the sketches and discussions that can be raised during this process students will better understand concepts related to energy resources and power generation as well as the stages for measuring energy, revealing losses and inefficiencies of an energy system. After the end of the activity, show to your students the 2nd, 3rd, and 4th part of the "Interview with an Electrical Engineer" to further discuss these topics. This activity can be combined with activity 1 and see how the sketches might change if a renewable energy source was used instead.

Figure 5: Still from the videos "Interview with an Electrical Engineer"

Possible questions to initiate the dialogue:

- What is an electrical grid?
- How much energy is needed to switch on a light bulb?
- How different types of light bulbs can affect energy consumption?

Links to videos and material that can help with the activity and the experiment:

- Power source activity: https://cleanet.org/resources/41901.html
- "Electricity – "sources and uses": https://www.youtube.com/watch?v=ja8U4bFhEGQ
- Insights from an electrical engineer: https://youtu.be/WaFkhiH5zrw https://youtu.be/Z2UnfwxPjJg https://youtu.be/_n4KJCGCjic

ACTIVITY 5:

“Talk” with experts

The aim of this activity is to introduce students to the challenge of energy production as has been experienced by experts, scientists or activists who have worked on it.

Below you can find the recorded interview with Dr. Barbara Alimisis, who talks about her remarkable experience in establishing medium-size wind turbines in rural Peru.

Figure 6: Still from the interview

Watch the interview and raise discussion in the class:

- How do wind turbines contribute to the local communities in Peru according to the expert?
- What changes do you think these communities might experience as a result?
- Why did the expert emphasize the importance of renewable energy solutions like wind turbines?
- Based on the expert's experiences, what have you learned about the role of renewable energy in sustainable development?
- What was the biggest takeaway for you from this interview?

Links to the video of the interview:

- Link: https://youtu.be/i8WKE3jK3D4

ACTIVITY 6:

With Arts as a Lens

Using arts as a lens, students can explore the interplay between Science, Technology, culture, and creative expression. This approach not only enhances creativity but also deepens students' understanding of climate-related concepts.

Ideas for Arts Integration:

Resource Example:

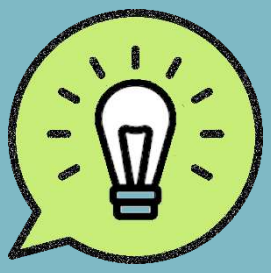
Use the article "A Brief History of Wind Energy for Artists" to connect the historical and artistic aspects of wind energy with STEM topics. The article traces the evolution of wind energy from ancient Egypt's use of wind-powered boats to modern wind turbines. It highlights key developments, such as the first windmills in China and Persia, the proliferation of windmills in the 17th century Netherlands, and the creation of electricity-generating wind machines in the late 19th century. The article also brings forward artistic interpretations of wind energy, including windcatchers in architecture and kinetic sculptures by contemporary artists like Anthony Howe. Fostering interdisciplinarity: Collaboration with colleagues from different disciplines enriches the learning experience by integrating diverse perspectives and expertise.

Rembrandt van Rijn (Dutch, 1606 – 1669). The Mill, 1645/1648, oil on canvas, Widener Collection 1942.9.62, National Gallery of Art.

Figure 7:

"The Mill", painting of Dutch painter Rembrandt van Rijn

ADDITIONAL TIPS FOR TEACHERS



Fostering interdisciplinarity:

Collaboration with colleagues from different disciplines enriches the learning experience by integrating diverse perspectives and expertise.

Community engagement

Engaging the community and inviting external experts can provide students with real-world insights and practical knowledge about climate change and renewable energy.

Ideas for Community Engagement:

Guest Speakers: Invite experts to the classroom to share their experiences and perspectives on energy, alternative, and renewable energy sources. This firsthand knowledge can inspire and educate students.

Interactive Sessions: Encourage students to prepare questions for guest speakers to make the sessions more interactive and engaging.

Multimedia Resources: Show short videos of interviews with experts to provide additional viewpoints and foster a deeper understanding of the topics discussed.

PROJECT LINK

GLOSSARY

Energy carrier: a substance (fuel) or sometimes a phenomenon (energy system) that contains energy that can be later converted to other forms (Wikipedia: https://en.wikipedia.org/wiki/Energy_carrier)

Low carbon fuels: materials that provide fewer emissions than fossil fuels

Microgrid: A microgrid is a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid.

Net zero fuels: material that provide zero carbon emissions

Turbine: a machine that transforms rotational mechanical energy into electrical energy. At its most basic, a turbine includes a shaft with a rotor featuring blades on one end and an electric generator on the other. The blades are driven by water, wind, or steam, causing the rotor to spin. Within the generator, a coil of metal wire is positioned inside a large magnet. As the shaft rotates, it turns the metal coil within the magnetic field, generating an electric current through induction.

Wind energy: electrical energy derived from the mechanical energy of a TURBINE which moves due to the action of the wind.

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[7] Ritchie, H. (2022) “Primary, secondary, final, and useful energy: Why are there different ways of measuring energy?”, Published online at OurWorldInData.org, Retrieved from: 'https://ourworldindata.org/energy-definitions' [accessed April 2024]

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Sustainable Housing

DESCRIPTION

As mentioned in “Energy production key challenge”, Housing is one of the three largest greenhouse gas emitting sectors in the world. Energy used in buildings accounts for 17.5% of greenhouse gas emissions, of which 10.9% comes from residential buildings and 6.6% from commercial buildings [1]. In addition to this energy consumption, that comes from “operational” facilities used in buildings (heating or cooling systems, lighting, boilers etc.), there is a significant amount of energy used for their construction. Carbon emissions from the production of building materials, such as cement, steel and aluminum account for 37% of global emissions [2]. In terms of "operational" emissions, the design strategies adopted in recent years to make buildings sustainable have already led to a reduction in carbon emissions, and it is estimated that if these strategies continue, emissions will be reduced by 50% or 75% over the next few decades [2].

In general, and in relation to sustainable design, there are four common features, namely energy efficiency, water conservation, indoor environmental quality and sustainable materials. [3]. Energy efficiency refers to strategies that reduce energy consumption, such as the incorporation of energy-efficient systems and renewable energy sources like solar panels, wind turbines, geothermal systems, integration of smart technologies to monitor energy use, as well as the use of proper insulation to prevent heat loss, resulting in both reduced emissions and cost saving [3, 4]. In this direction, the installation of recycling and composting stations (especially in flat apartments) is another potential strategy [4].

Water conservation design strategies such as rainwater harvesting systems, grey water recycling, but also the adoption of drought-tolerant landscaping ideas (e.g. using drought-tolerant plants) can have a major impact on saving water supplies [3]. Indoor environmental quality is about the health of the residents of a building. This means using design strategies to maximize natural light and ventilation to create a healthy indoor climate. Finally, sustainable materials is about using materials that are renewable and recycled, require little energy to be produced, and ideally can be sourced locally [3].

DESCRIPTION

In terms of building materials, there is still a lot to be done. Some mitigating actions that can be taken in this direction include avoiding unnecessary extraction and production of materials, as well as switching to renewable and reusable materials that can be used for the creation of the building structure [2]. Clay bricks for instance are one such material. According to the British Ceramics Confederation the carbon emissions associated with the production of clay bricks are lower than those associated with the production of concrete bricks [5]. Furthermore, in the UK, the carbon emissions from clay brick production have been reduced by 8 kg of CO2/m2 from 2015 to 2021, while it is estimated that their production will be close to net-zero by 2050 [5]. Other very promising sustainable materials are bamboo, cork, recycled concrete, rammed earth and adobe which are globally used as alternative solutions on building houses, and sometimes as self-sustaining materials [3].

However, housing does not only have a significant impact on climate change. It is also affected by climate change [6]. Extreme weather such as heavy rainfall, floods, wildfires and tsunamis as well as rising sea levels, threaten not only people living in coastal areas or on islands, but also those belonging to vulnerable communities [7]. This issue has been included in the “Guidelines for the Implementation of the Right to Adequate Housing” (2019) [8], which suggests among other things, the need to adopt strategies and measures to help preserve communities living near waterways or coastlines, as well as the need to develop and maintain safe and environmentally friendly housing constructions. Such strategies can also prevent resettlement, reducing the problem of unnecessary production of materials for new buildings and the problem of deforestation to create new housing.

LEARNING OBJECTIVES

In this section students will learn:

1. What is the impact of housing in climate change
2. How housing is affected by climate change
3. How a building can turn into sustainable thus reducing carbon footprint
4. What is insulation and how it works
5. What renewable materials can be used in construction

They will also be able to:

1. explain what a sustainable building is
2. identify ways to minimize operational emissions
3. suggest strategies for creating sustainable buildings
4. suggest strategies for preventing buildings from natural disasters

Interdisciplinary focus

Engineering

Technology

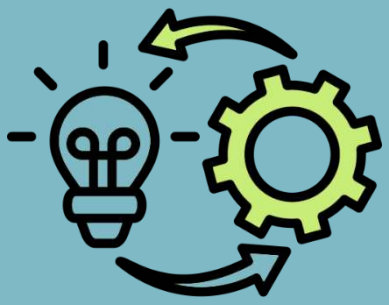
Material Science

METHODOLOGY

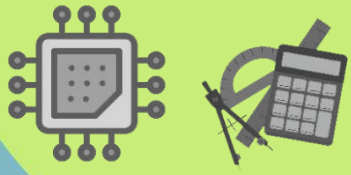
Methods for introducing this topic in class:

- brainstorming
- experiment with different materials to see how insulation works
- representation of information through sketches or the creation of paper models

IMPLEMENTATION SCENARIO



Nadia is a middle school teacher and she is about to introduce her students to the key challenge of Sustainable Housing. To engage her students in the learning process and inspire them to act as agents of change, Nadia considers starting with a brainstorming session. She shows her students some videos about sustainable buildings and relevant design strategies. She discusses with her students the benefits of sustainable construction, in terms of reducing the carbon footprint of buildings, and the methods that can be used to achieve such solutions. She then divides her students into teams of 2 or 3, and encourages them to write down their ideas on how they could make their school building a sustainable building. She asks each team to present their findings in plenary, thus exchanging ideas. In this way, she also hopes to inspire her students to work together on a collaborative project to create a paper model of their school, incorporating some of the ideas they have recorded



PROPOSED ACTIVITIES

ACTIVITY 1:

Calculating carbon footprint

In this activity, students will become aware of their impact on carbon footprint and greenhouse gas emissions based on their lifestyle (in terms of accommodation and household). Create a number of fictional characters who live in different types of houses and have different lifestyle choices in relation to house living. Divide your students into teams of 2 or 3 and ask each team to calculate the household carbon footprint of these characters, by using a free carbon footprint calculator. These calculators have a series of questions about the size of a house and its “operational” systems as well as questions about daily habits related to living in the house. Then ask your students to compare the results and think of ways to reduce the carbon footprint of these personas.

Possible questions to initiate the dialogue:

- Which parameters do you think have the biggest impact on a house's carbon footprint?
- Why is it important to reduce carbon footprint?
- Which heating method has less impact on a house's carbon footprint?
- What design strategies can we adopt to reduce a home's carbon footprint?

Links to videos and material for initiating the dialogue:

- EarthGen Carbon Calculator: https://earthgenwa.org/learning-resources/carbon-calculator/;
- WWF Footprint Calculator: https://footprint.wwf.org.uk/
- 8Billion Trees Household carbon calculator: https://8billiontrees.com/carbon-offsets-credits/carbon-ecological-footprint-calculators/household/

ACTIVITY 2:

Discussing about sustainable buildings

The objective of this activity is to familiarize students with the term “sustainable buildings” and to encourage them to reflect on design strategies. To begin this activity, you could show the class the video “Interview with an Architect Engineer” or/and some short videos about sustainable buildings and best practices for designing them. You can then discuss with your students the methods presented and the importance of designing sustainable buildings. At the end of the discussion, you can divide the students into teams of 2 or 3 and ask each team to write down some design strategies to make the school building sustainable. To make the task more engaging, ask each team to present their ideas in the plenary.

Figure 1: Still from the video “Building materials and the climate: Constructing a new future”

Figure 2: Still from the video “Interview with an Architect Enginner”

Possible questions to initiate the dialogue:

- What is a sustainable building?
- Can you name some design strategies to create a sustainable building?
- Can you name a sustainable building in your city?
- Why do you think it is important to design sustainable buildings?

Links to useful material and interview:

- Interview with an Architect Engineer: https://youtu.be/fTPTeDSh-5g
- Best Practices for Sustainable Building Design and Construction/ Green Building Construction: https://www.youtube.com/watch?v=oFMV3e4yYL8
- Building materials and the climate: Constructing a new feature: https://www.youtube.com/watch?v=igST9xrXi4o
- Greywater recycling: https://www.youtube.com/watch?v=y8kipgTJDUw
- Energy Efficient and Sustainable building design principles for East Africa: https://www.youtube.com/watch?v=kXmq-uICmTM
- 10 sustainable Global Home Design Trends: https://www.novatr.com/blog/sustainable-home-designs-trends

ACTIVITY 3:

How insulation works? - Experiment

The aim of this activity is to help students understand, through an experiment, how insulation works and why it is important to use insulation in a building. Students will see how the temperature of a glass cup of hot or cold water changes when the cup is wrapped in different materials, such as foil, bubble wrap, wool, paper and plastic. To carry out this experiment you will also need a kettle of water, a thermometer for liquids and a cold/hot pack. Ask your students to wrap the glass cups in different materials and pure hot water inside. In 15 minutes measure the temperature of each cup using a thermometer for liquids. Ask students to write down the temperature and discuss the results. Alternatively, ask your students to wrap the bottom side of the cup in different materials. Pure hot water inside the cups and place them over some cold packs. Ask your students to measure the temperature of the water after 5 minutes, write down the measurements and discuss the results. This experiment will allow your students to see how different materials can maintain temperature for longer periods of time, while introducing them to the concepts of heat transfer by convection and radiation. At the end of the experiment, you can discuss with your students why insulation is important in a building.

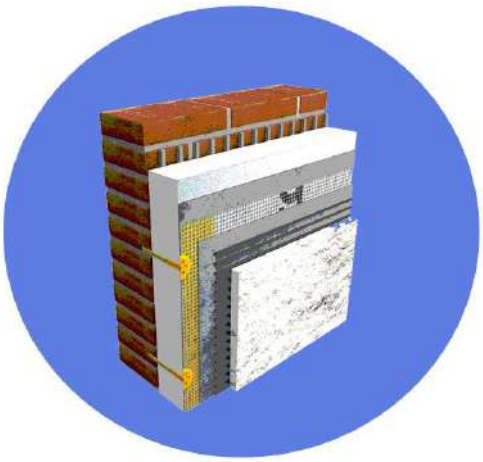


Figure 3:

Layers of insulation

Materials needed for the experiment:

Several glass cups, a kettle, foil, bubble wrap, wool, paper, plastic/membrane, a thermometer for liquids, some cold/hot packs.

Possible questions to initiate the dialogue:

- How does insulation work?
- Why is it important to insulate our houses?
- How is heat transferred?
- What materials are good insulators?

Links to videos and material that can help with the activity and the experiment:

- Facts about insulation: https://www.funkidslive.com/learn/curious-kate/curious-facts-insulation/
- Stay warm with thermal insulation: https://www.sciencebuddies.org/stem-activities/stay-warm-with-thermal-insulation
- Insulation: https://kids.britannica.com/students/article/insulation/275068
- How animals stay warm with blabber: https://www.scientificamerican.com/article/bring-science-home-animals-stay-warm-with-blubber/

ACTIVITY 4:

Discussing about renewable materials

The aim of this activity is to familiarize students with renewable materials that can be used to construct buildings and the importance of switching to such solutions in relation to climate change. Using the information provided in the following links, or the interview with a civil engineer (with expertise in the use of such renewable materials) students can compare different materials such as clay bricks, adobe, concrete and rammed earth to identify their advantages in terms of carbon emissions from their production but also for their maintenance. You can also encourage them to think in which parts of a building these materials could be used and search if there are examples of buildings that have been completely constructed by such materials. They can also identify locations in their city or country where such materials can be found, and identify a number of other parameters that can be taken into account when making decisions about the resources used in the construction of a building (e.g. Availability of materials close to home, which can also minimize carbon emissions from their transport).

Figure 4: House made of cork (retrieved from the second link of the list)

Possible questions to initiate the dialogue:

- Can you name some renewable materials?
- What adobe and rammed earth are?
- How can renewable materials contribute to the design of sustainable buildings?

Links to useful materials:

- Let's compare bricks: www.brick.org.uk/uploads/downloads/Clay-v-Concrete-Brick-A-Comparative-Guide-2022-v.3.f1675190626.pdf)
- Cork house: https://www.architecture.com/awards-and-competitions-landing-page/awards/riba-regional-awards/riba-south-award-winners/2019/cork-house
- All about Adobe - sustainable and energy efficient: https://www.thoughtco.com/what-is-adobe-sustainable-energy-efficient-177943

ACTIVITY 5:

With Arts as a Lens

Using arts as a lens, students can explore the interplay between Science, Engineering, Technology, culture, and creative expression. This approach not only enhances creativity but also deepens students' understanding of climate-related concepts.

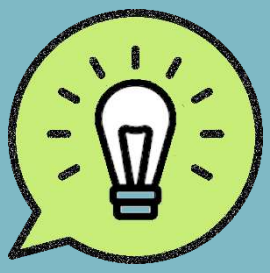
Encourage your students to search the internet for sustainable buildings around the world, and note the different design approaches (e.g., the addition of solar panels, shadings on the building façade, green roofs, rainwater harvesting systems etc.). Encourage them to also search for sustainable buildings made of renewable materials (such as adobe or bamboo) and observe how these materials affect the overall design of the building. Then encourage them to consider how the school building might look like if a number of such sustainable strategies were adopted, and ask them to make drawings or paintings to illustrate the different design approaches. You can also encourage students to build a 3D model of their school building using recycled materials and make the necessary changes to the building envelope. This hands-on activity can help them to understand how art can be related to more technical aspects of design.

Figure 5: Image of a bamboo building, retrieved from the first link

Useful links to draw inspiration:

- Sustainable Art in Architecture: Crafting Eco-Friendly Spaces with a Conscience: https://www.artistuprising.com/post/sustainable-art-in-architecture-crafting-eco-friendly-spaces-with-a-conscience
- The Art of Designing Sustainable Buildings: https://www.thefuturepositive.com/blog/art-designing-sustainable-buildings /
- Edible Architecture – The art of sustainable building: https://buildingspecifier.com/edible-architecture-the-art-of-sustainable-building/

ADDITIONAL TIPS FOR TEACHERS



Community engagement

Engaging the community and inviting external experts can provide students with real-world insights and practical knowledge about climate change and sustainable housing.

Ideas for Community Engagement:

Parental Engagement: You can invite parents who work in relevant fields (e.g., construction, environmental science) to share their expertise and experiences with the students.

School community Engagement: You can host community events such as a “Sustainable Living Fair” where students can present their project and ideas to the broader school community.

PROJECT LINK

GLOSSARY

Adobe: a mixture of earth and straw made into bricks and dried in the sun (https://dictionary.cambridge.org/dictionary/english/adobe)

Building envelope: The building envelope includes all the building components that separate the indoors from the outdoors.

Grey water: water that has been used before (e.g. for washing), that can be stored and used again (https://dictionary.cambridge.org/dictionary/english/greywater)

Rammed earth: building material made by compacting certain soils (https://www.britannica.com/technology/rammed-earth)

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[1] Ritchie, H. (2020) “Sector by sector: where do global greenhouse gas emissions come from?”, Published online at OurWorldInData.org, Retrieved from: https://ourworldindata.org/ghg-emissions-by-sector (accessed April 2024)

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[4] Mota, L., Leite, E. and Ghasemi, V. (2024) “Exploring the impact of climate on lodging establishments: a systematic literature review”, Quality & Quantity International Journal of Methodology, available at: https://link.springer.com/article/10.1007/s11135-024-01834-9

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[5] “Climate change and the right to housing”, United Nations (accessed April 2024 at: https://www.ohchr.org/en/special-procedures/sr-housing/climate-change-and-right-housing)

[6] “Climate Action: For billions of people around the world, housing is the frontline in the fight against climate change”, World Economic Forum, (accessed April 2024 at: https://www.weforum.org/agenda/2024/01/3-ways-we-can-use-housing-to-adapt-to-the-climate-crisis/)

[7] “Guidelines for the implementation of the right to adequate housing”, United Nations (accessed April 2024 at: https://www.ohchr.org/en/special-procedures/sr-housing/guidelines-implementation-right-adequate-housing)

[8] Image retrieved from: https://www.thebrecklife.com/passive-house-sustainability-guide/

Biodiversity

DESCRIPTION

Biodiversity (or biological diversity) is an umbrella term used to describe the variability of life that can be found in an area of the Earth [1 - 4]. In this sense, biodiversity represents a wide range of living forms, including animals, plants, fungi and microorganisms (e.g. bacteria) [2,3]. It is therefore considered a measure of the species richness (namely the number of different species) of an area, the genetic diversity within each species, and the ecosystems produced by these species [1]. Biodiversity can be studied at many levels, from a large-scale example, such as a forest or a coral reef and the species that live in it, to a smaller scale example, such as a pond [5]. Biodiversity is essential to our very existence, as many things that are inextricably linked to our well-being (e.g., food, clean water, medicines, accommodation, climate stability, economy etc.) depend on healthy natural ecosystems [3, 4]. In fact, it is considered to be the most prominent natural solution to climate change [4]. Ecosystems such as the forests, oceans and wetlands are considered as "carbon sinks", capable of absorbing around 50% of the greenhouse gasses produced by human activities [4].

How biodiversity has been affected:

In recent years, biodiversity has been massively threatened mainly by excessive human activity (e.g. overfishing of oceans, deforestation, pollution of air and water etc.), which is also a driving force of climate change. The use of land for food production is one of the main drivers of biodiversity loss [4]. The conversion of land to farmland can lead to the gradual extinction of many animals as their habits change dramatically [4]. Moreover, the steady rise in temperature leads many animals (and plants) to migrate to colder climates (which are closer to the poles), causing major disruptions to the entire ecosystem [4]. The higher the temperature, the greater the risk of species extinction, both on land and in the oceans.

According to WWF's Living Planet Report, wildlife population have declined by 69% in the last 50 years [6]. Additionally, based on IPBES reports, it was estimated in 2015 that climate change had pushed one in six species to the brink of extinction globally [7]. Preventing the loss of biodiversity is one of the 17 Sustainable Development Goals set by the United Nations. Goal 15 (Life on Land) aims to protect all forms of life on Earth, including the protection of ecosystems, the prevention of the loss of plant and animal species, and stop actions that lead to the degradation of the Earth (deforestation, drought etc.) [8].

DESCRIPTION

How biodiversity can be preserved:

One way to stop the loss of biodiversity is to rethink how we are using resources and reduce carbon emissions. Saving energy or changing transportation methods to be more sustainable (using bicycle, public transportation or walking) can help in reducing our carbon footprint. Another way is to find new ways of feeding the population on Earth without causing further damage to the environment. Growing plants or/and the creation of pollinator gardens by choosing plants that attract pollinators such as bees, butterflies or birds, are also important actions for maintaining biodiversity.

LEARNING OBJECTIVES

In this section students will learn:

1. What biodiversity is
2. How biodiversity is measured
3. How climate change affects biodiversity
4. Ways to study biodiversity
5. Ways to prevent biodiversity

They will also be able to:

1. explain the concepts of biodiversity and ecosystem
2. identify how different species form an ecosystem
3. propose sustainable solutions on the problem

Interdisciplinary focus

Biology

Science

Technology

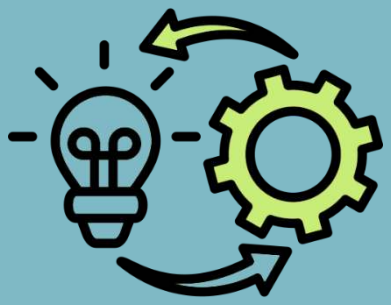
Mathematics

METHODOLOGY

Methods for introducing this topic in class:

- brainstorming
- studying ecosystems, food chains and food webs
- identify how different species contribute to mitigating of climate change
- talk with experts

IMPLEMENTATION SCENARIO



Alex is a middle school teacher and is about to introduce her students to the key challenge of Biodiversity. To engage the students in the learning process and inspire them to act as agents of change, Alex considers starting with a brainstorming session on biodiversity. She begins by showing a series of videos that explain the basic concepts surrounding biodiversity and how it is inextricably linked to human existence and the viability of the Earth. After a thorough discussion that she has with the students on the basic terms connoting biodiversity (i.e. ecosystem, food chain etc.), Alex encourages her students to go to the school garden and record all the different living and non-living forms that make up the ecosystem of the school garden, in order to study how all these different species interact. After this study, the students are encouraged to present their findings in class. Based on the results, Alex is thinking of encouraging her students to create an educational game in Scratch that will inform players about the role of each species not only in a food web, but also their role in mitigating climate change.

PROPOSED ACTIVITIES

ACTIVITY 1:

Studying biodiversity

The aim of this activity is to familiarize students with the concept of biodiversity by learning what biodiversity is and why it is important for our own existence. Through a number of videos (such as those in the “Links” section) teachers can initiate the dialogue with students on topics such as what biodiversity is, how we can describe biodiversity, what species shape biodiversity and what are their characteristics, how it is affected by climate change and why it is important to be preserved. Through this activity students will not only learn about biodiversity, but they will also realize how broad this topic is and why it is so crucial to our own existence.

Figure 1: Still from the video “Our Planet – What is biodiversity?”

Possible questions to initiate the dialogue:

- What is biodiversity?
- How is biodiversity related to CO2 emissions?
- How climate change affects biodiversity?
- What mitigating actions can we do to preserve biodiversity?

Links to videos and material for initiating the dialogue:

- Our Planet – What is biodiversity?: https://www.youtube.com/watch?v=US58f-SwO0k
- What is biodiversity?: https://www.youtube.com/watch?v=y18o0mACCQs
- What is biodiversity? – Definition, Types and Importance: https://www.youtube.com/watch?v=rclOz8Fsbmg
- How does climate change affect biodiversity? https://www.youtube.com/watch?v=XFmovUAWQUQ

ACTIVITY 2:

Analyzing an ecosystem

An ecosystem is the complex of living organisms, their physical environment and all their interrelationships in a given unit of space (Definition from Britannica). In this sense, an ecosystem can be perceived as anything that contains life and the interactions between living and non-living forms, from a pond or a garden, to a coral reef or a forest, and where biodiversity can be studied. With this as a basis, this activity aims to encourage students to study biodiversity in a small-scale case study, by studying and analyzing the ecosystem of the school garden. Divide your students into teams and ask them to visit the school garden and record all the living and non-living forms, by making notes and sketches or by taking pictures. Then ask them to organize the recorded species into different categories (e.g., living, non-living, animated, static etc.) and think about the impact of each species on others. Ask each team to present their research in plenary and discuss their findings, emphasizing the diversity of species that can be found in such a small-scale example, and the amount of interactions that need to take place to preserve this ecosystem.

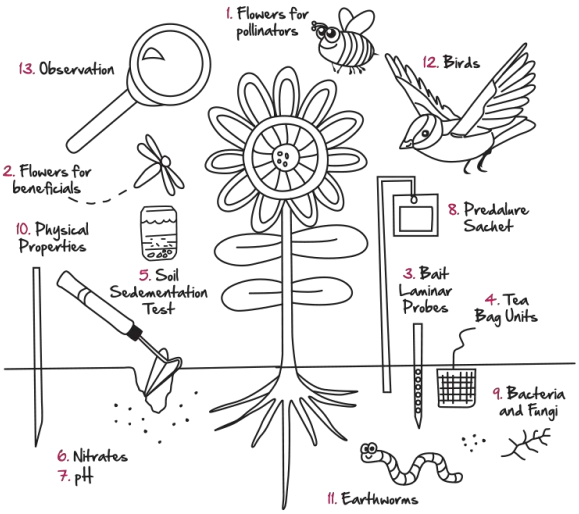


Figure 2: Diagram retrieved from link "How does your garden grow"

Possible questions to initiate the dialogue:

- How many different species have you recorded?
- What kind of interactions take place in the school garden ecosystem?
- Are there any species that act as pollinators? How do these species affect the school garden ecosystem?
- Do you think that non-living forms have an impact on the school garden ecosystem?
- Do you think that the school garden ecosystem has an impact on the school microclimate?

Links to additional material:

- Ecosystem: https://education.nationalgeographic.org/resource/ecosystem/
- Ecosystem: https://www.britannica.com/science/ecosystem
- How does your garden grow: https://www.theorganicstore.org.nz/how-does-your-garden-grow/ (interesting diagram for drawing inspiration)

ACTIVITY 3:

Animals and plants that contribute to the reduction of CO2 emissions

There are many different species on land and in the sea that can help reduce CO2 emissions. In this activity the students will learn about these species and the ways they contribute to the reduction of CO2 emissions. You can either use the file “Biodiversity-activity.pdf” or create your own document, and have a short quiz with your students, asking them to relate the species shown to the way they contribute to reducing emissions. After completing the quiz, divide your students into teams and ask each team to prepare a short presentation for one of the species included in the quiz (or for one of the species presented here) including information on their habits, how they contribute to the reduction of emissions and how they are currently threatened. Then ask each team to present the results of their research in the plenary to discuss the impact of each species on biodiversity and climate change.

Figure 3: Image from the biodiversity activity

Possible questions to initiate the dialogue:

- Do all species contribute to the reduction of CO2 emissions in the same way?
- Can you name some of the different mechanisms or/and ways that different species have of reducing emissions?
- How climate change affects these species?

Links to quiz and additional material:

- Biodiversity activity: https://drive.google.com/file/d/1rlPECc5tj9atogd6T9HQNy-yv9AWXB5W/view?usp=sharing
- Planting hope: https://www.wwf.org.uk/what-we-do/planting-hope-how-seagrass-can-tackle-climate-change
- Wild carbon: https://wildcarbon.oneearth.org/?page=2&page=1
- African forest elephant: https://www.worldwildlife.org/species/african-forest-elephant

ACTIVITY 4:

Analyzing a food chain

"*A food chain shows how energy is transferred from one living organism to another via food*" (Food chains and food webs - WWF).

Species on Earth (animals or plants) are to some extent interdependent. This relationship can be illustrated through the food chain and the food web (i.e., a composition of many food chains). Studying food chains and food webs can help us to understand the role that each species can play in an ecosystem in terms of transferring energy and nutrients (through food), thus maintaining the balance of an ecosystem. Therefore, in this activity the students will explore the various interrelationships that exist between different species. Divide your students into teams and ask them to use one of the online games for creating food chains (find the relevant link in the list below). At the end of each short task, discuss the results with your students and encourage them to think about the broader categories of a food chain (e.g. plants, carnivores etc.) and how they interact, how these food chains can form part of a food web, or to think about scenarios where one of the species in a chain becomes extinct, thus discussing why it is important to study food chains to find ways of conserving an ecosystem. You could consider combining this activity with the third activity and encourage your students to create food chains for the species they find in the school garden.

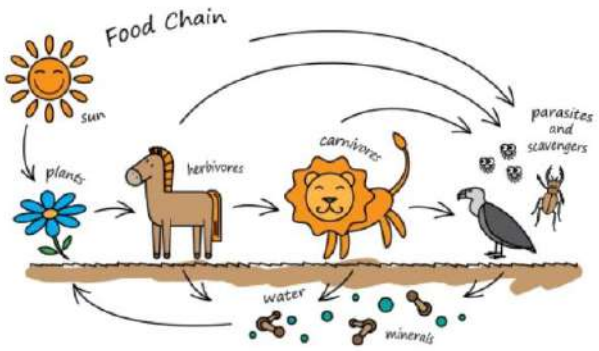


Figure 4: Image from the "Explore Nature's Web: Food Chain Game Quiz"

Possible questions to initiate the dialogue:

- Why is it important to study food chains and food webs?
- What are the broad categories of a food chain or web?
- What will happen to a food chain or web if one species becomes extinct?

Links to food chain games and to additional material for initiating the dialogue:

- Food chain game:
- Build a food chain game:
- Explore Nature's Web: Food Chain Game Quiz:
- Food chains and food webs:
- Marine food chains and biodiversity

ACTIVITY 5:

With Arts as a Lens

According to the “Five artworks about climate change” article, artists from different eras and fields have been inspired by climate change.

For example, Edward Burtynsky’s fascination with photographing industrially altered landscapes was sparked by his upbringing near a General Motors plant in his hometown. In this context, Burtynsky captured images of the controversial Three Gorges Dam construction in China’s Hubei Province [9]. Although the dam was intended to boost electricity production and improve the region's shipping capabilities, its construction devastated farmland, displaced over a million people, and caused significant ecological disruptions, including landslides and a decline in biodiversity [9].

Woth this in mind, you can use the photograph “Three Gorges Dam” (or any of the four other artworks referred in the article) to raise the dialogue in class about biodiversity and climate change. Through Burtynsky’s artwork for example, you can discuss with your students about the complex relationship between technological progress and its impact on communities and ecosystems. Thoughts and emotions evoked can be also documented and lead further the discussion in the class.

Figure 5: Edward Burtynsky, Dam #6, Three Gorges Dam Project, Yangtze River, China, 2005, chromogenic print, Corcoran Collection (Gift of the Artist), 2015.19.5277

Links to the article:

- Five artworks about climate change: https://www.nga.gov/stories/five-artworks-about-climate-change.html

ADDITIONAL TIPS FOR TEACHERS

Community engagement

Engaging the community and inviting external experts can provide students with real-world insights and practical knowledge about climate change and biodiversity.

Ideas for Community Engagement

School community Engagement: Join as school partners the Earth.org [10] and become members of a broader community sharing your interest and actions for a brighter and greener future!

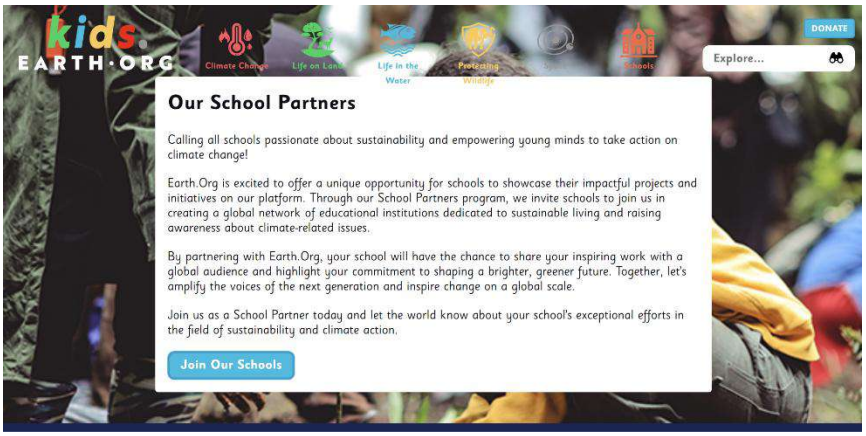


Figure 6: Calling of Earth.org

PROJECT LINK

References

[1] “Biodiversity”, Britannica official webpage, (accessed April 2024 at: https://www.britannica.com/science/biodiversity)

[2] “Biodiversity”, National Geographic official webpage (accessed April 2024 at: https://education.nationalgeographic.org/resource/biodiversity/)

[3] “What is biodiversity? - Why It’s under threat and why it matters”, WWF official webpage (accessed April 2024 at: https://www.worldwildlife.org/pages/what-is-biodiversity)

[4] “Biodiversity – Our strongest natural defense against climate change”, United Nations official webpage, (accessed April 2024, at: https://www.un.org/en/climatechange/science/climate-issues/biodiversity#:~:text=Biological%20diversity%20%E2%80%94%20or%20biodiversity%20%E2%80%94%20is,evolution%2C%20increasingly%20influenced%20by%20humans.)

[5] “Biodiversity”, National Wildlife Federation (accessed April 2024 at: https://www.nwf.org/en/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Biodiversity)

[6] “Living Planet Report 2022”, WWF official webpage (accessed April 2024 at: https://livingplanet.panda.org/en-US/)

[7] IPBES (2016) The Methodological Assessment report on scenarios and models of biodiversity and ecosystem services, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Copyright © 2016, ISBN: 978-92-807-3569-7

[8] “Sustainable Development Goal: 15 – Life on Land”, United Nations official website (accessed April 2024 at: https://sdgs.un.org/goals/goal15)

[9] Five artworks about climate change: https://www.nga.gov/stories/five-artworks-about-climate-change.html

[10] Kids Earth.org https://kids.earth.org/schools/

Effects of higher temperatures on the human body

DESCRIPTION

Wet Bulb Temperature effect: The Wet Bulb Temperature effect, describes the critical threshold at which high temperatures and humidity affect the body's ability to thermoregulate through sweating. Humans have an upper physiological limit for heat and humidity, which is at a wet bulb temperature (TW) of 35°C (more recent research suggests 31°C, depending on current physical activity) [1]. Exceeding this limit can have health effects and even death [1]. According to [1] a significant upward trend in the frequency of extreme humid warmer events worldwide is identified. Assuming unchanged emission trajectories, the wet-bulb temperature of 35°C could be regularly exceeded in parts of South Asia and the Middle East by the third quarter of the 21st century.

Current data: The increasing frequency and intensity of extreme, warm and humid weather poses a serious challenge that has far-reaching implications for health, job performance and the economy. Adaptation strategies and research on health effects are considered to be urgently needed [1]. According to the latest climate report from the Copernicus Climate Change Service and the World Meteorological Organization dated 22 April 2024, in 2023 Europe experienced a record number of “very strong heat stress” days (Figure 1), while the heat-related mortality in Europe has increased by 30% over the last 20 years due to climate change [2, 3]. This trend will continue.

Current medical research suggests that there were about 45,000 heat-related deaths in Europe in 2022 alone, caused by the higher temperatures of climate change [4]. As highlighted by [5] older people are particularly susceptible to heat stress and heat-related illnesses. This group is particularly at risk due to reduced physical adaptation responses to heat stress and possible drug-induced restrictions on body temperature regulation. Therefore, and as suggested by [1] it is urgent to understand and respond to the physical realities and projections of extreme heat and humidity conditions to protect human health and productivity in a warming climate.

Critical temperature ranges and Critical Wet Bulb Temperature for Humans:

The critical wet-bulb temperature values (Twb,crit) at which heat stress becomes uncontrollable vary depending on environmental conditions [5]. Specifically, according to [5] it was found that:

- In hot, dry environments, the critical values are between 25°C and 28°C.
- In warm, humid environments, the critical values are closer together and are in the range of 30°C to 31°C.

DESCRIPTION

A study [5] of young healthy adult performing daily activities at moderate metabolic rates to determine the critical wet temperature value at which heat stress becomes uncontrollable, showed that none of the subjects reached the theoretical limit of 35°C, and the average critical values were significantly below this value, especially in hot and dry environments.

However, according to the study and analysis of weather station data by [1], wet bulb temperatures of 35°C have already been reached in some coastal regions. This surpasses previous climate models, which predicted such events only in the middle of the 21st century.

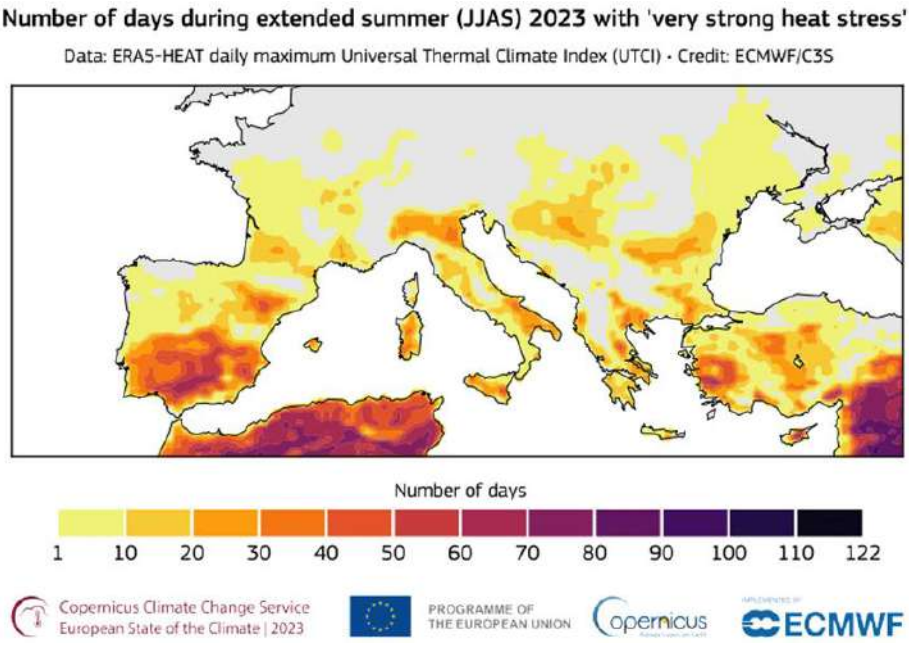


Figure 1: Number of days that experienced 'very strong heat stress' (UTCI between 38 and 46°C) during June, July, August and September 2023., Image retrieved from [2]"

LEARNING OBJECTIVES

In this section students will learn:

1. The influence and importance of the wet bulb temperature for their own body
2. The correlation between weather-related wet bulb temperature and body surface temperature
3. The cooling effect of evaporating water: evaporative cooling
4. The measurement of this effect depending on different environmental conditions (humidity, outside temperature, wind, etc.)
5. The influence of physical activity on your own body temperature
6. The difference between core body temperature and surface body temperature and the necessary temperature gradient

Interdisciplinary focus

Physics

Biology

Geography

Arts

Social topics

METHODOLOGY

This document integrates physics and biology to explore the impact of the Wet Bulb Temperature effect on the human body's thermoregulation abilities. This is particularly relevant in the context of rising global temperatures and humidity, which can overwhelm the body's ability to cool itself through sweating.

The implementation scenario described in this document is the same one that you will carry out with your students in the context of the linked project.

METHODOLOGY

In addition to the description of the implementation scenario, which sets the background and the objectives of the linked project, this document contains some introductory activities that will help you to incorporate this topic in the classroom and allow students to reflect on the impact of these phenomena in their lives. The activities included can also pave the way of an initial theoretical discussion that will help students to explore the theory behind why humans have specific limits to the Wet Bulb Temperatures.

This document will prepare your students to further investigate the effect of the Wet Bulb Temperature by following the methodology contained in the linked project.

Here's a summary of the methodologies used in the linked project to bridge physics and biology:

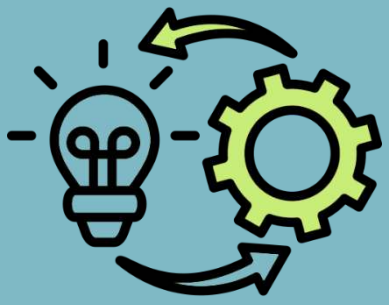
1. Experimental Learning through several experiments designed to teach the physical phenomenon of evaporative cooling, which is a crucial biological cooling strategy for humans. These experiments include a) Evaporative Cooling Demonstration, b) Quantitative Measurement of Evaporative Cooling, and c) Qualitative Analysis of Wet Bulb Temperature

2. Data Analysis: Incorporating historical data on heatwaves and current research findings to demonstrate the immediate relevance of these physical-biological interactions. This includes analysis from notable studies like those by Colin Raymond et al., which highlight the occurrence of extreme humid-heat conditions surpassing previous climate models.

3. Classroom Integration: suggestions on incorporating these topics into classroom settings, allowing students to engage with and understand the practical implications of these phenomena in their lives.

4. Theoretical Discussion: delving into the theory behind why humans have specific limits to the Wet Bulb Temperatures they can tolerate, emphasizing the critical thresholds beyond which heat stress becomes detrimental to health.

IMPLEMENTATION SCENARIO



Frame story for this scenario

In the future, our earth will no longer look like it does now. The changes will probably mean that we will have to find our way around a 'new planet'.

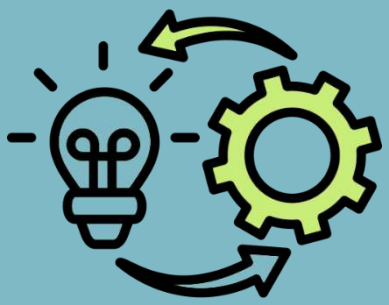
To this end, students like you are getting together for a scientific project to understand these new environmental conditions and make them measurable. This is the only way to develop strategies for survival in this increasingly hostile reality.

When looking at current research results, one recognizes environmental conditions such as high ambient temperatures combined with high humidity levels. These environmental circumstances are constantly intensifying.

The educational challenge goes through 3 important stages:

1. understanding the effects of these changes,
2. measuring them and,
3. developing strategies for dealing with them (based on the measurement that have been done) in the future.

IMPLEMENTATION SCENARIO



Number of sessions: 4 - 5

In the Wet Bulb Temperature project, we will cover the Wet Bulb Temperature effect, which describes the critical threshold at which high temperatures and humidity affect the body's ability to thermoregulate through sweating. Scientific studies, including the work of Colin Raymond et al. [1], show that conditions that exceed this threshold – for example, with the combination of "temperature above 35°C" and "humidity above 90%" – are already occurring more frequently than predicted by previous climate models. Recent research, however, assumes a much lower value [5].

Historical data on heat waves, such as those in Europe in 2003 and Russia in 2010, illustrate the severe consequences of such extreme conditions. Furthermore, recent research shows that such extreme wet-bulb temperatures are already being recorded in regions such as South Asia, the Middle East coast and the southern coast of North America.

These developments underscore the urgency of reducing global greenhouse gas emissions. The continuous increase in CO2 levels makes it clear that the measures taken so far to mitigate climate change are not sufficient.

Students should therefore learn the connections in a playful and experimental way and thus recognise the relevance for their own lives. The knowledge of the basic physical-biological relationships (outside temperature – humidity – body temperature) should be practiced and internalized.

PROPOSED ACTIVITIES

ACTIVITY 1:

Introduction to “Wet Bulb Temperature”

The aim of this activity is to introduce students to the effect of Wet Bulb Temperature by making them aware of some recent events related to heat stress days across Europe. Students will first read the following articles and then discuss their content in teams or in plenary to reflect on emerging issues regarding human resilience to extreme heat.

Possible questions to initiate the dialogue:

- What does this mean for us as humans in the near future?
- What is the limit of what a human body can bear?
- What effects will such heat waves have on our bodies?
- How can we protect ourselves from this – or what do we need to know to protect ourselves from it?

Newspaper articles:

Mega heat in Baden-Württemberg. Heat record pulverized: Here it was 38 degrees | July 13, 2023

link

Baden-Württemberg has experienced the hottest weekend of the year so far – even in a nationwide comparison. 38.0 degrees Celsius were measured on Sunday afternoon in Waghäusel-Kirrlach (Karlsruhe district).

It was also hot in the larger cities of the southwest, such as Mannheim (37.6 degrees), Freiburg (36.2 degrees) and Stuttgart (36.1 degrees).

According to historical weather data, the humidity was around 30% at 2 p.m. Source

Temperatures above 50 degrees Celsius will also become possible in Europe | February 06, 2024

link

Partners of the Xaida consortium also analyzed the heatwaves in which temperatures rose to more than 50 degrees Celsius in the USA and China in July 2023. This level of heat can be fatal. Southern Europe was also exceptionally hot in the summer of 2023, and according to a study by ETH Zurich, temperatures of more than 50 degrees Celsius will also be possible here in the future. […]

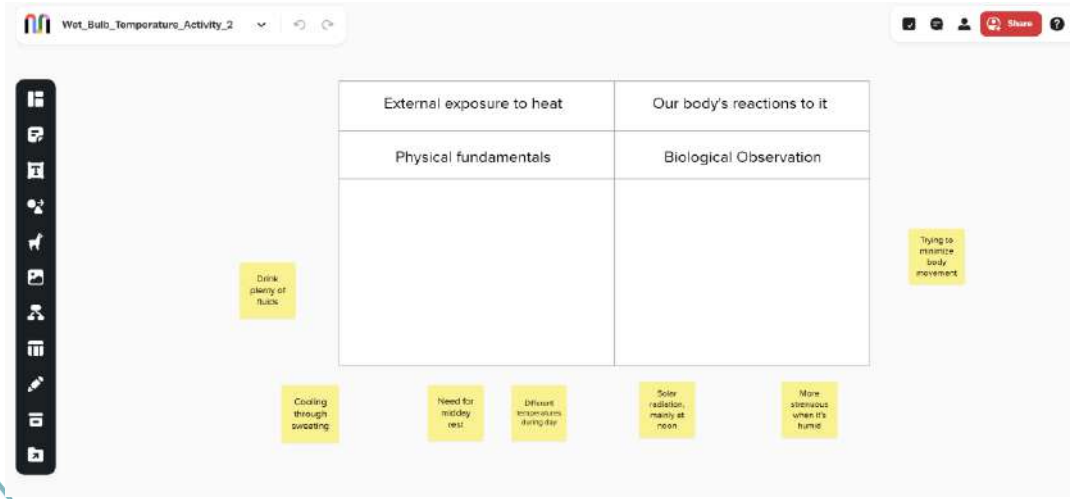
ACTIVITY 2:

Wet Bulb Temperature body reaction

In this activity the students will understand how our bodies react to heat and why the increasing heat can become dangerous for our bodies and our health. They will do this by understanding how physics and biology work together. The following table shows how the physical (physical principles on external heat exposure) and the biological (Biological observation of our body's reaction to heat) perspectives work together.

External exposure to heat	Our body's reaction to it
Physical Fundamentals	Biological Observation
§ Solar radiation, mainly at noon § Different temperatures during the day § More strenuous when it's humid	§ Sweating cools § "Siesta": Midday rest § Drink plenty of fluids § Moving little

Click on the picture below to open the **mural collaborative working area**. Present the semi-structured table to the class and discuss with them where each sticky note should be placed and why. Discuss with your students the implications of each entry in terms of heat distress.



Link to mural collaborative working area.

ACTIVITY 3:

Elaboration phase: physical basis of “evaporative cooling”

This activity is a developmental stage that will prepare students for the experiments included in the linked project. Ask your students to answer the following questions to introduce them to the concept of evaporative cooling. To make this activity more interactive, create a Mural template with the following questions and ask your students to answer them by adding sticky notes. Then read their answers and discuss the concept of evaporative cooling.

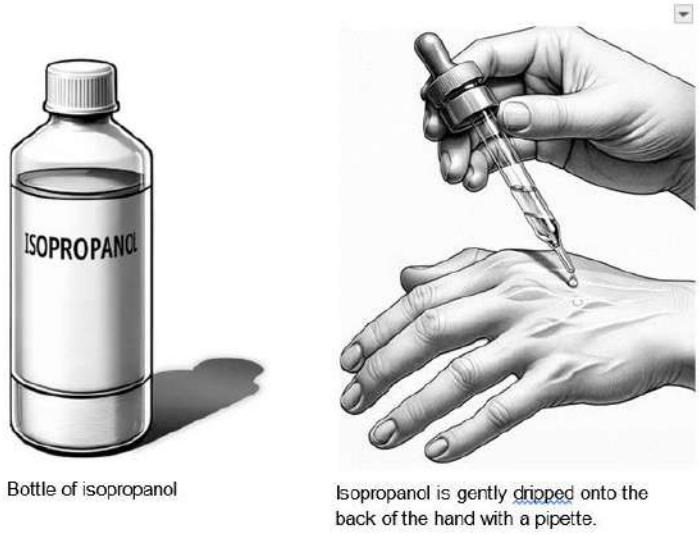


Figure 2: Image from the experiment

Possible questions to initiate the dialogue:

- - Why do we sweat?
  - It cools us down: evaporative cooling.

- -What is "evaporative cooling"?
  -When a liquid evaporates, it takes heat with it.

- -What does this mean?
  -This means that it is actually a "heat entrainment through evaporation"

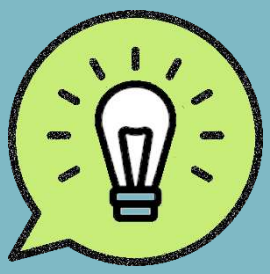
ACTIVITY 4:

Talk with an expert

The aim of this activity is to introduce students to the challenge of Wet Bulb Temperature as has been experienced by a physics teacher (Thomas Joerg). Watch the interview and lead a class discussion on the main concepts surrounding the Wet Bulb Temperature effect.

Link to interview:

- https://youtu.be/uheO7-sQBks



ADDITIONAL TIPS FOR TEACHERS

Contextualize recent events:

Familiarize yourself with the recent heat events in Europe, especially the ones mentioned in the articles, to provide students with concrete examples. Help students gain understanding on how these events relate to Wet Bulb Temperature and its impact on human health, emphasizing the severity and frequency of extreme heat events due to climate change. You may provide additional ones from areas that are more relevant for your group of students.

Prepare discussion questions and boost deeper conversation:

If time permits, you can use the provided questions to guide the discussion, but also prepare follow-up questions to deepen the conversation. Encourage students to think about the implications of extreme heat on society, health, and infrastructure. Facilitation techniques like think-pair-share, group discussions, collection of sticky-notes and plenary sessions can help students engage more deeply with the material.

Community Involvement:

Plan a community art exhibition or a presentation event where students can showcase their work and educate others about the wet bulb effect and climate change.

ADDITIONAL TIPS FOR TEACHERS

With Arts as a lens:

Encourage students to explore artworks that depict high temperatures, summer scenes, or intense heat. These can include paintings, photographs, sculptures, or digital art and can be used to convey messages about climate change and wet bulb effect.

Examples of artworks:

Figure 3: 1888 Vincent Van Gogh- Le Semeur

Figure 4: Summer heat on busy beach by **Gerard Hegarty**

With Arts as a Lens

Encourage your students to visit the "Art of Heat" virtual gallery inspired by the wet bulb temperature effect, where Art and STEM come together to help you explore the challenges of climate change in a creative way!

Figure 5: The ART of Heat Virtual Gallery

Through the Lens of Social Science

Below you can see the titles of key news stories related to heatwaves that challenged various places in 2024.

More than 1300 people died during the Hajj in Mecca due to heat stress (temperatures more than 50°C):

https://edition.cnn.com/2024/06/24/asia/indonesia-hajj-heatwave-burial-intl-hnk/index.html

At least 40.000 cases of heat stroke during heat wave in India:

https://edition.cnn.com/2024/06/21/india/india-delhi-nighttime-heatwave-climate-intl-hnk/index.html

Greece shuts Acropolis to protect tourists from blistering heat

https://edition.cnn.com/2024/06/12/climate/greece-shuts-acropolis-heat-climate-intl/index.html

Figure 6: Retrieved online from https://en.wikipedia.org/wiki/Heat_illness#/media/File:Heat_stroke_treatment,_Baton_Rouge,_2016_Louisiana_floods.jpg

Through the Lens of Social Science

Questions for Classroom Discussion

Encourage students to explore ways **to prevent, protect,** and **prepare** their community for extreme heat events. Discuss the topic in class and **work together** to develop possible solutions. Ideally, link the discussion to practical actions that can be implemented at **school** or **community** level.

Some examples for relevant questions could be:

Here are some guiding questions:

- How can you protect your classmates during extreme heat conditions, such as high wet bulb temperatures? What rules of conduct should be established?
- Does the school building need adaptations to improve safety and comfort? For example, should it have water dispensers, warning signs, designated cooling zones, or specially prepared rooms?
- If extra rooms are available, should they be opened to people outside the school, such as passersby, during extreme heat events?
- Should support be extended to nearby kindergartens or retirement homes to help protect vulnerable groups from the effects of extreme heat?

Encourage students **to think critically, brainstorm practical solutions,** and consider how they can take action to build a more heat-resilient community!

GLOSSARY

Humidity: Humidity is the amount of water vapor in the air. If there is a lot of water vapor in the air, the humidity will be high. The higher the humidity, the wetter it feels outside. (retrieved from: https://education.nationalgeographic.org/resource/humidity/)

Heat stress: includes a series of conditions where the body is under stress from overheating. (retrieved from: https://www.ehs.iastate.edu/heat-stress)

Evaporative cooling: the process of removing heat from a surface due to the evaporation of water (https://study.com/academy/lesson/what-is-evaporative-cooling-definition-process.html)

References

[1] Raymond, C, Matthews, T. and Horton, R.M. (2020) “The emergence of heat and humidity too severe for human tolerance”, Science Advances journal, Vol 6, Issue 19, DOI: 10.1126/sciadv.aaw1838

[2] “Heat-Related Mortality in Europe Up 30% in Past 20 Years, Report Reveals”, EARTH.ORG official webpage, (accessed April 2024 at: https://earth.org/heat-related-mortality-in-europe-up-30-in-past-20-years-report-reveals/)

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[5] Vecellio, D., Wolf, S.T, Cottle, R.M. and Kenney, L.W. (2022) “Evaluating the 35°C wet-bulb temperature adaptability threshold for young, healthy subjects (PSU HEAT Project), journal of Applied Physiology, Jan 2022, https://doi.org/10.1152/japplphysiol.00738.2021

Sustainable Food

DESCRIPTION

How can we build sustainable food systems between health, culture, economy, and environment?

The food choices we make every day hold profound significance, shaping not only our personal health but also the future of our planet. A well-balanced diet – rich in fruits, vegetables, nuts, and whole grains – provides essential nutrients that energize the body, support overall well-being, and reduce the risk of chronic diseases such as heart disease, diabetes, and obesity [1,2,3]. These foods are foundational to a healthy lifestyle, helping individuals stay strong, focused, and resilient.

However, the impact of our diets extends far beyond individual health. The way food is produced, consumed, and wasted has serious implications for the environment. For example, the production of red meat and processed foods often demands vast resources, leading to deforestation, water shortages, and significant greenhouse gas emissions [1,27,28]. By choosing more plant-based foods, we can reduce our ecological footprint, conserve vital resources like water and land, and contribute to mitigating climate change [2,3,4,9]. A sustainable diet protects ecosystems and ensures that future generations will have access to the resources they need to thrive [1,4].

Yet, food is not just a matter of nutrition or sustainability – it is deeply connected to the fabric of our cultures and identities. What we eat is shaped by traditions, personal preferences, and social norms, making discussions about diet both deeply meaningful and often challenging [5,6,16,18,22]. Food connects families and communities, celebrates heritage, and reflects our values.

Changing long-held habits can feel like a loss of identity or tradition, even when such changes are necessary for health or environmental reasons. Recognizing and respecting these cultural dimensions is crucial when exploring how to promote healthier and more sustainable eating practices [2,5,6].

In addition to shifting diets, innovation in food production offers new possibilities for addressing global food challenges. Advances such as laboratory-grown meat, precision fermentation, and alternative protein sources provide promising solutions to reduce the environmental burden of traditional agriculture [7,17,18]. These technologies could drastically cut greenhouse gas emissions, conserve water, and spare land for biodiversity. However, they also raise important ethical and cultural questions. For instance, some religious groups question whether lab-grown foods align with their dietary laws, while others embrace technology as a way to fulfil their moral responsibility to care for the world [5,6]. Such concerns highlight the need for inclusive dialogue and careful consideration of diverse perspectives as we embrace new food technologies. [5,6]

DESCRIPTION

In this Challenge, we will explore how our food choices affect the environment, examining ways to balance individual needs, cultural heritage, and global sustainability. To deepen this exploration, we will look at two inspiring initiatives dedicated to advancing sustainable diets:

- The EAT-Lancet Commission on Food, Planet, Health: This international collaboration of 37 leading scientists from 16 countries has created the Planetary Health Diet – a flexible framework that promotes human health while respecting planetary boundaries. [2].
- The FEAST Project (Food systems that support transitions to healthy and sustainable diets): This European initiative seeks to make sustainable eating accessible, enjoyable, and practical for all. FEAST focuses on transforming food systems to create "win-win-win-win" outcomes for people, the planet, and both public and private sectors. As FEAST puts it: "We aim to make it easy for every person in Europe to eat a delicious, healthier, and more sustainable diet" [3].

By understanding the interplay between food, health, culture, sustainability, and innovation, we can empower ourselves to make informed decisions that honour our individual and collective needs, paving the way for a healthier, more equitable, and environmentally friendly food system.

LEARNING OBJECTIVES

In this section, students will:

1. Recognize the principles of the EAT-Lancet Commission's Planetary Health Diet and its role in promoting sustainability and health.
2. Develop an understanding of the environmental, health, and cultural dimensions of food choices.
3. Understand the importance of reducing carbon and water footprints through dietary choices as the most impactful individual actions for sustainability
4. Analyze the broader environmental impacts of food production, including land use, water use, and resource consumption.
5. Appreciate the health benefits of diets rich in plant-based foods compared to those based on animal products.
6. Critically evaluate the role of food innovation, such as lab-grown meat, in addressing sustainability challenges, while considering ethical, cultural, and religious perspectives.
7. Discuss the global challenge of feeding a growing population sustainably by 2050 and the need for systemic changes in food systems.

Interdisciplinary focus

Biology

Geography

Physics

Technology

Social science

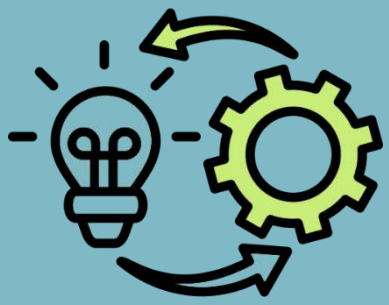
Engineering

METHODOLOGY

Methods for introducing this topic in class:

- online quizzes
- online calculators
- visiting virtual exhibition
- talk with experts
- mind map creation
- interactive graphs
- community event: collaborative cooking
- discussion and reflection

IMPLEMENTATION SCENARIO



Mark sat in the bustling school canteen, his usual lunch tray in front of him. As he took a bite of his beef sandwich, his mind wandered back to the lesson he had just taught. It had been one of his favorite subjects - climate change and the urgent need for action. But now, as he glanced around the room, he noticed something unsettling.

His students, many of whom had appeared so engaged in his class, were now sitting with trays piled high with burgers, steaks, and other meat dishes. The gap between their classroom ideals and lunchtime realities struck him hard. Mark realized that, despite their interest in the lessons, they weren't translating those values into their daily lives. They were mimicking the very behaviors that contributed to the problems they claimed to care about.

The irony was glaring, but instead of feeling frustration toward the students, Mark felt a deeper understanding. It wasn't enough to just tell them "stop eating meat." He realized the problem was much more complex – rooted in culture, habit, and a lack of deeper understanding. Changing minds wasn't as simple as giving a lecture; it required a shift in awareness that they had to develop on their own.

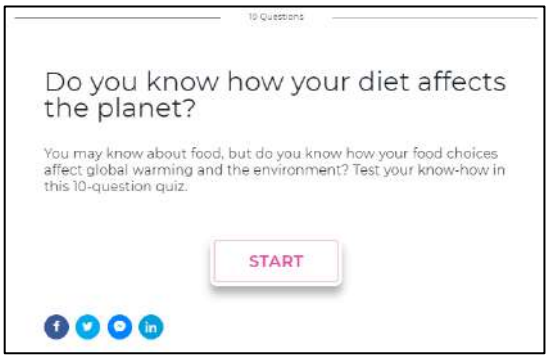
Inspired, Mark decided his next lesson wouldn't just be about climate change. Instead, he would take his students through the journey of how food is produced—where their burgers and steaks come from, the environmental cost, and the ethical dilemmas involved. He wouldn't preach; he would lay out the facts, allowing them to make the connections themselves. If they could see the full picture, perhaps the change would come from within, rather than from a command to "eat less meat." It was time, he realized, to help them think critically and make their own informed decisions. His next lesson will start in the school canteen.

PROPOSED ACTIVITIES

ACTIVITY 1:

Initiate a discussion about the environmental impact of food

Understanding the environmental impact of our food choices is essential for building sustainable habits. By taking an interactive online quiz, students can explore how food production affects the planet across multiple dimensions – such as greenhouse gas emissions, water consumption, land use, eutrophication, antibiotics overuse and biodiversity loss. This activity sparks discussion by connecting personal food habits to global challenges, encouraging reflection on how small changes can lead to meaningful environmental benefits.



Possible questions to initiate the dialogue:

- In this activity, we suggest starting by asking students to take a quiz from Columbia University and use some short videos from below: https://www.universityofcalifornia.edu/news/quiz-do-you-know-how-your-diet-affects-planet
  In case of a lack of internet connection, one can print out questions and ask for peer-marking
- After the quiz, students can share and compare their results to identify surprising aspects of the topic. We encourage students to create a mind map summarizing different aspects of the topic (to be developed during next activities)

Links to videos and material for initiating the dialogue:

- To address misconception found in the quiz, students can watch the video “The diet that helps fight climate change”, Vox and University of California: https://youtu.be/nUnJQWO4YJY?si=75EJpLmokcMeHSjZ (5:40)

ACTIVITY 2:

Calculating the Carbon Footprint of Different Meals

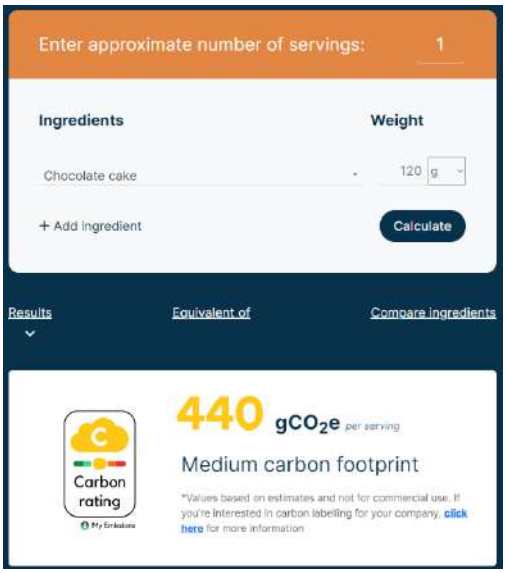
In this practical activity, students will calculate and compare the carbon footprints of various foods to understand their environmental impact.

The **My Emissions Food Carbon Footprint Calculator** is a free online tool allowing users to estimate their recipes' carbon footprint. The calculator estimates the greenhouse gas emissions associated with the meal by inputting ingredients and their quantities. This tool is designed to help individuals and food companies understand the environmental impact of their food choices and explore ways to reduce their carbon footprint.

We suggest dividing students into small groups and assigning each group a selection of foods or asking them to write down what they eat for breakfast or lunch. Then launch the following website and ask to fill in the ingredients:

https://myemissions.co/resources/food-carbon-footprint-calculator/

Groups can present their findings, comparing the carbon rating of different meals. By going into “Equivalent of” section, they can compare impact of their meal to other activities



Possible questions to initiate the dialogue:

- Which foods have the highest carbon and water footprints?
- How can dietary choices reduce environmental impact?
- What product can you remove or replace by substitute to lower your meal carbon footprint?

ACTIVITY 3:

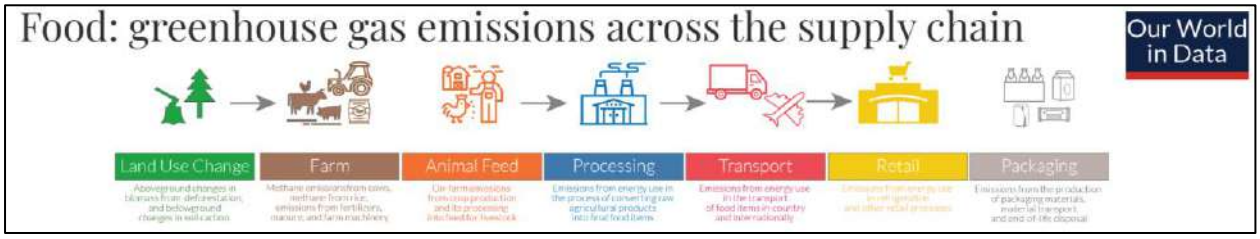
Food Supply Chain Analysis

In previous activities, students explored the total emissions associated with food without looking into what drives those emissions. This activity examines the various stages of the food supply chain – production, processing, transportation, and retail – and their individual environmental impacts. By analyzing supply chains, students will identify key inefficiencies and propose sustainable solutions to reduce the overall footprint of our food systems [4,11].

Possible questions to initiate the dialogue:

- How did your breakfast land on your dish?

  We encourage students to create a schematic diagram or an artwork illustrating the way “from the field to our home” – students can focus on their meal or be separated into groups and assigned various products: some plant-based and meat-based or some local-based and delivered from distant continents. After initial work or in case of struggle teacher can share this heading from the Our World in Data chart:



- Which stage of this process generates the highest greenhouse gas emissions and why?

  To answer this question, let’s display on a projector (or ask student’s to open the website on their devices) the website with an interactive chart breaking down the emissions of chosen products by emission of particular stage (land use, farming, animal feed, processing, transport, retail, packaging, losses): https://ourworldindata.org/grapher/food-emissions-supply-chain

  Alternatively, the following graphics can be displayed. If print in color is available and students like puzzles, we recommend printing this diagram and cutting it in pieces, letting students recreate stripes:
  https://ourworldindata.org/food-choice-vs-eating-local

Links to videos and material for initiating the dialogue:

We encourage to watch the whole video of Jamie Oliver's TED presentation “Teach every child about food” (21:53): https://www.youtube.com/watch?v=go_QOzc79Uc

Tip: If time is limited, it is recommended to watch the segment from 11:14 to 12:00, which highlights how children who primarily consumed processed foods struggled to recognize raw ingredients or determine their origins (e.g., whether they come from trees or the ground).

ACTIVITY 4:

How to deal with food waste?

Food waste is a critical issue with significant environmental, economic, and social implications. Approximately 13.2% of food is lost after harvest during various stages, such as transport, storage, and processing. Additionally, about 19% of food is wasted at the retail, food service, and household levels. This waste contributes to 8% to 10% of total agrifood system emissions, with methane – a greenhouse gas at least 28 times more potent than carbon dioxide – being a significant byproduct [13,14,15,16].

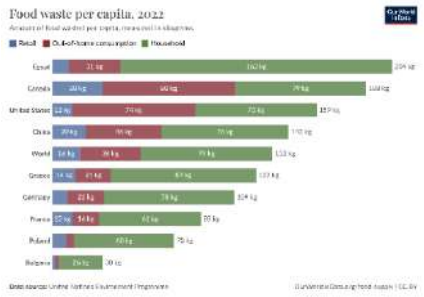
Possible questions to initiate the dialogue:

- "Have you heard of **The International Day of Awareness of Food Loss and Waste (IDAFLW)**?"

  The United Nations General Assembly designated 29 September as the International Day of Awareness of Food Loss and Waste (IDAFLW). The day is co-convened by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP) and the day's events are led jointly by the two organisations.

  https://www.stopfoodlosswaste.org/theme

- "Do you know in which country food waste is the highest?"

  Using the "Our World in Data: Food Waste Per Capita" graph, students will identify countries with the highest and lowest per capita food waste, compare their own country's data, and analyze possible reasons for these differences, such as economic development or cultural practices. They will present their findings in a brief report or discussion, concluding with one actionable recommendation to reduce food waste in their community.

  https://ourworldindata.org/grapher/food-waste-per-capita

- "Could you quantify the amount of food wasted in your home?"

  Students will use a **food waste journal** to track and record the amount and types of food wasted in their households over a week. The journal can include categories like portion leftovers, spoiled food, and expired items. This tool helps students reflect on waste patterns, identify common causes, and explore actionable ways to reduce food waste at home. The following activity would be to find a way to reduce the amount of waste in upcoming weeks.

  One way of reusing waste is **composting** – please refer to STEAM4Climate Toolbox for details!

Links to videos and material for initiating the dialogue:

Follow the interactive walk "Journey of Food" or display the infographics

- https://www.unep.org/interactives/journey-of-food
- https://wedocs.unep.org/bitstream/handle/20.500.11822/43006/The_journey_of_food.pdf

ACTIVITY 5:

Laboratory meet – tradition vs technology

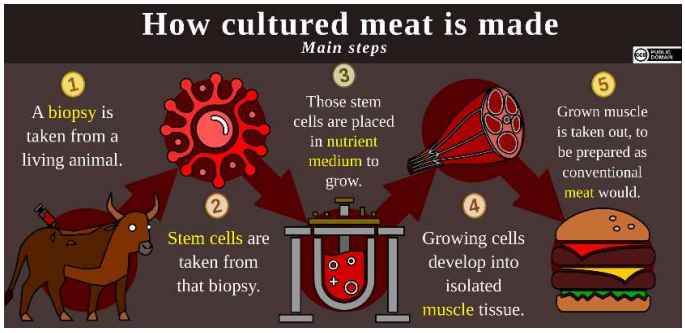
The environmental impact of livestock farming is undeniable, with significant contributions to greenhouse gas emissions, deforestation, water consumption, and land degradation. Yet, meat and dairy products hold deep cultural and religious significance for many communities, making dietary shifts complex – especially for those for whom a transition to a vegan or vegetarian diet feels unimaginable. This activity introduces students to the innovative world of lab-grown meat and precision fermentation as sustainable alternatives to traditional food production. By combining science and technology with cultural sensitivity, students will explore how these advancements can address environmental challenges while respecting diverse dietary needs. Linked to the accompanying video, this session bridges the gap between tradition and technology, encouraging critical discussions about the future of food.

Possible questions to initiate the dialogue:

- "In what ways food production impacts the environment?"
  Watch our STEAM4Climate interview with an expert in genetics and molecular biology, dr Bogna Borowiec, to reflect on various aspects of the environmental impact of modern food production system:
  https://youtu.be/l3yf4yvwev8

- "What if we can have a meet, but environmentally friendly and cruelty-free?" To understand the science and concerns behind the food production innovation, listen to this podcast:
  https://open.spotify.com/episode/4yCKSioorfxTL6x7PaunOR

- One can also study the infographics below:



- "Are there religious considerations regarding cultivated meat?" – To initiate discussion around this topic, students are encouraged to explore popular discussions and follow debates relevant to religions of their choice by referring to these articles:

  "Halal cell-based meat: Singapore's Fatwa Committee approves Muslim consumption"

  https://www.foodingredientsfirst.com/news/halal-cell-based-meat-singapores-fatwa-committee-approves-muslim-consumption.html

  "Lab-grown meat can be kosher and halal, experts say"

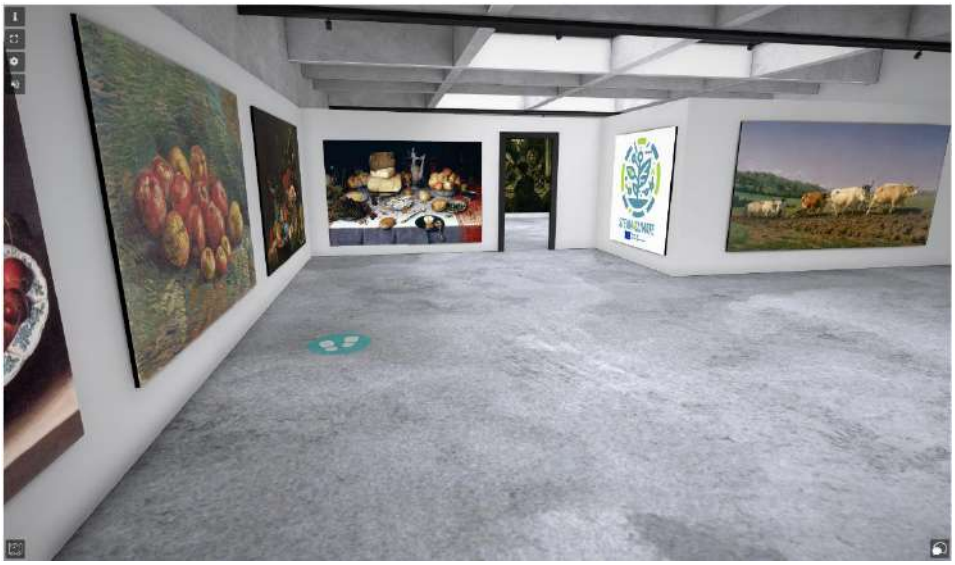
  https://www.reuters.com/markets/commodities/lab-grown-meat-can-be-kosher-halal-experts-say-2023-09-11/

ACTIVITY 6:

With Arts as a Lens – agriculture through centuries

This activity invites students to explore the evolving relationship between agriculture and society through the lens of art. Using a curated virtual gallery featuring iconic paintings and art references, students will examine how agriculture has been portrayed across centuries – from historical works like Millet's The Gleaners and van Gogh's The Potato Eaters to more modern interpretations. Students will reflect on how these artworks capture the cultural, economic, and environmental aspects of farming in their respective eras.

https://www.artsteps.com/view/678d404e3a9a4ca16a06f668



Possible questions to initiate the dialogue:

- Take a look at satellite images of your region (for example, from Google Earth) and reflect on how much land we need to transform to feed ourselves.

Links to videos and material for initiating the dialogue:

- "Food in Painting. From the Renaissance to the Present"

  https://press.uchicago.edu/ucp/books/book/distributed/F/bo3640314.html
- "Centuries-Old Paintings Help Researchers Track Food Evolution"

  https://www.smithsonianmag.com/smart-news/how-paintings-can-teach-us-about-evolution-food-180975381/
- Oregon State University - College of Agricultural Sciences' Art About Agriculture program, including "Art About Agriculture Competition and Touring Exhibition 2022: The Sustainable Feast"

  https://agsci.oregonstate.edu/art

ACTIVITY 7:

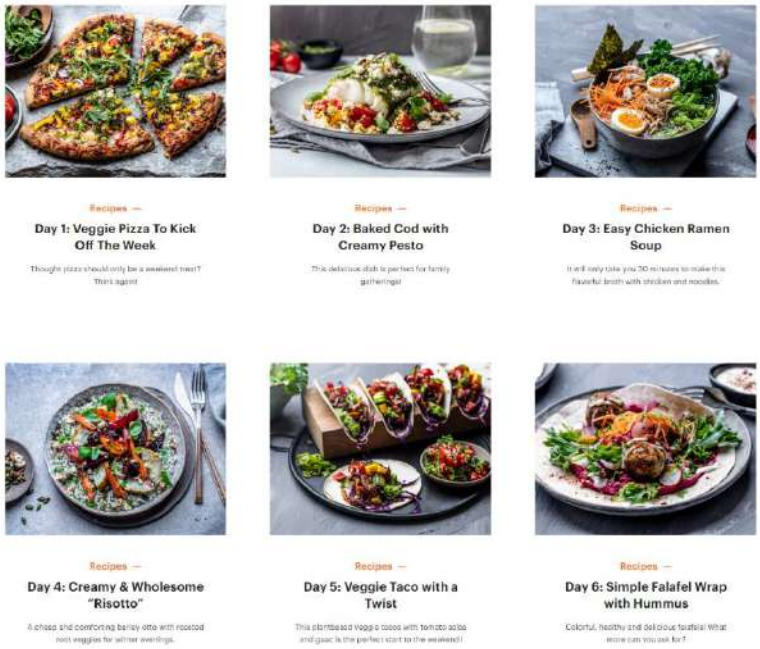
Cooking together

In this activity, students will collaborate to design a sustainable meal plan that minimizes carbon and water footprints while maintaining nutritional balance. Using resources like the Planetary Health Recipes from the EAT-Lancet Commission, students will explore how to incorporate plant-based ingredients, reduce food waste, and make environmentally conscious choices.

Once the meal plan is complete, students will prepare one of the meals together, applying their knowledge of sustainable cooking while fostering teamwork through a hands-on, practical experience. Engaging the school canteen in this activity could have a significant impact, but cooking at home and sharing the results with peers is also a valuable and meaningful practice.

After the previous activities, students should be able to discuss the following issues: What factors should be considered when designing a sustainable meal plan? How can plant-based ingredients be incorporated without compromising nutritional balance? How do carbon and water footprints differ across various types of ingredients? What are the environmental benefits of reducing food waste in meal planning? Now to operationalize their knowledge, let's invite them to visit websites with climate-friendly recipes and make their choice:

https://www.earthday.org/eatmoreplants/



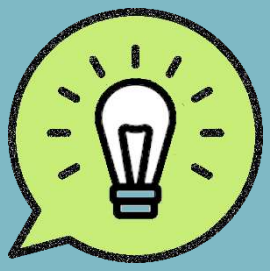
https://eatforum.org/planetary-health-recipes/

To sum up we encourage to download "Activity Book - Eating healthy matters ", Food and Agriculture Organization of the United Nations: https://openknowledge.fao.org/server/api/core/bitstreams/7c280b0b-e4bb-4a65-a216-f1d15be7ad8d/content

Further collaboration and extension:

We encourage you to get acquainted with **The FEAST Project,** especially with "**the Living Lab** activities supporting the local food challenges" dedicated to schools, like one in Avignon: https://feast2030.eu/livinglabs-overview

ADDITIONAL TIPS FOR TEACHERS



If possible, we recommend engaging the wider community: involving the school canteen, parents, local farmers, or sustainability experts in the learning process. Guest speakers, field trips, or community events can add valuable insights.

We also recognize that topics like food security or dietary changes can be personal. Approach discussions with sensitivity and encourage respectful dialogue.

PROJECT LINK

Beyond Carbon Footprint: Water Footprint, Land Use, and Other Considerations – we encourage you to play Phygital Board Games for Behavioural Change which you can find in the STEAM4Climate Toolkit.

If your facility allows it, we also encourage you to consider the “Urban Farming” projects to explore techniques like vertical gardens, hydroponics, and indoor farming, showing how we can produce food sustainably in urban spaces.

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[8] “Quiz: Do you know how your diet affects the planet?”, University of California: https://www.universityofcalifornia.edu/news/quiz-do-you-know-how-your-diet-affects-planet

[9] “The diet that helps fight climate change”, Vox and University of California: https://youtu.be/nUnJQWO4YJY?si=75EJpLmokcMeHSjZ

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[14] “Food loss and waste account for 8-10% of annual global greenhouse gas emissions; cost USD 1 trillion annually”, United Nations Climate Change website: https://unfccc.int/news/food-loss-and-waste-account-for-8-10-of-annual-global-greenhouse-gas-emissions-cost-usd-1-trillion

[15] Interactive chart “Food waste per capita”, Our World in Data: https://ourworldindata.org/grapher/food-waste-per-capita

[16] “Journey of Food: Explore eight critical steps in the journey of food”, United Nation Environmental Programme interactive website: https://www.unep.org/interactives/journey-of-food and their report: https://wedocs.unep.org/bitstream/handle/20.500.11822/43006/The_journey_of_food.pdf

[17] STEAM4Climate video with dr Bogna Borowiec: https://youtu.be/I3yf4yvwev8

[18] “The real fight over fake meat”, Today, Exlained podcast, March 2024 https://open.spotify.com/episode/4yCKSioorfxTL6x7PaunOR

[19] STEAM4Climate virtual gallery: https://www.artsteps.com/view/678d404e3a9a4ca16a06f668

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[21] “Centuries-Old Paintings Help Researchers Track Food Evolution”, Smithsonian Magazine: https://www.smithsonianmag.com/smart-news/how-paintings-can-teach-us-about-evolution-food-180975381/

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[23] “Planetary Health Recipes”, EAT-Lancet Commission: https://eatforum.org/planetary-health-recipes/

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Chapter 4

Further reading and collection of resources

This chapter presents a number of additional resources such as material for further reading and inspiration.

Insights from the Experts

In this section, you will have the opportunity to hear directly from experts in the field of climate change or STEAM related areas. Through a series of short interviews, these professionals share their insights, experiences, and the challenges they face in their work. Each video provides a unique perspective on key issues related to climate change, offering valuable knowledge and practical information that can enhance your understanding and inspire your teaching practices.

Energy Production: Light up a life in Peru

Dr. Barbara Alimisis talks about her experience in establishing medium-size wind turbines in rural Peru. Together with a team of fellow volunteers she constructed and installed wind turbines in the communities that have no reliable access or no access at all to electricity, prioritizing schools.

Link: https://www.youtube.com/watch?v=HfkU6awRaKE

The Wet Bulb Temperature effect

Thomas Joerg from Kepler Pforzheim Gymnasium in Germany explains the Wet Bulb temperature effect, its connection to climate change, and its impact on the human body.

Link: https://www.youtube.com/watch?v=Y5fo60Wk8Ic

Electricity generation and energy consumption

Dr. Konstantinos Pipis provides a comprehensive overview of electricity generation and the transmission process. He highlights energy efficiency through examples like LED lights and efficient appliances, with a call to reduce waste through mindful usage. Finally, he underscores the future role of Smart Grids and consumers, who will soon actively manage their energy consumption using smart meters and other technologies.

Links:

Part 1: https://youtu.be/Q7EU9WgIGJk?si=96nzRpbLvN6YYYbn

Part 2: https://youtu.be/hNyya6KJGgk?si=lxGKGN6eo4ZBIN8r

Part 3: https://youtu.be/xveSilV3yjw?si=1SZJJ3AepVHo1AmG

Part 4: https://youtu.be/8y12oasPtkM?si=M0cA-gau3JCwdAHh

About Sustainable Housing

Vasilis Mavratzas (expert in sustainable building and building technologies and new materials), explains what sustainable building is and how it can be designed. He guides us through the role of eco-friendly materials and the role that renewable energy sources can play as well as building technologies and key decisions based on the climate of the country where the building is located. Lastly, he shares his perspective on the challenges and future opportunities in the field of sustainable building.

Link: https://youtu.be/fTPTeDSh-5g

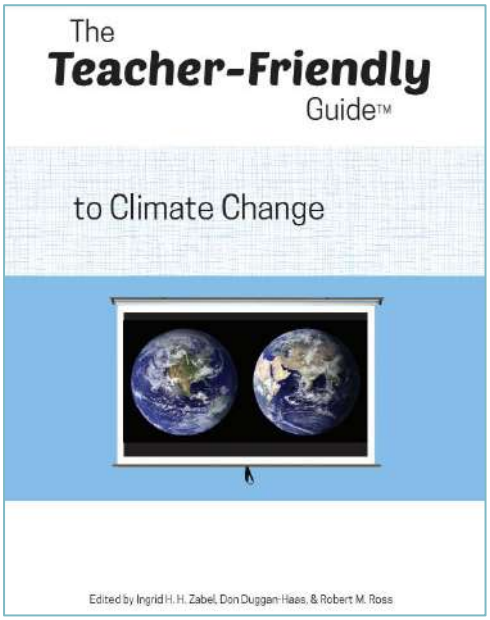
Impact of food production system

Join Dr. Bogna Borowiec as she examines the environmental challenges of modern agriculture, from deforestation and biodiversity loss to excessive greenhouse gas emissions, water usage, and soil degradation.

Link:

https://www.youtube.com/watch?v=I3yf4yvwev8

Further reading and exploration



The Teacher- Friendly Guide to Climate Change

This guide provides educators with comprehensive resources and scientifically accurate information on climate change. It covers fundamental concepts, the impacts of climate change on various systems, and strategies for mitigation and adaptation. The guide aims to enhance teachers' understanding and ability to effectively communicate climate science in the classroom

Link

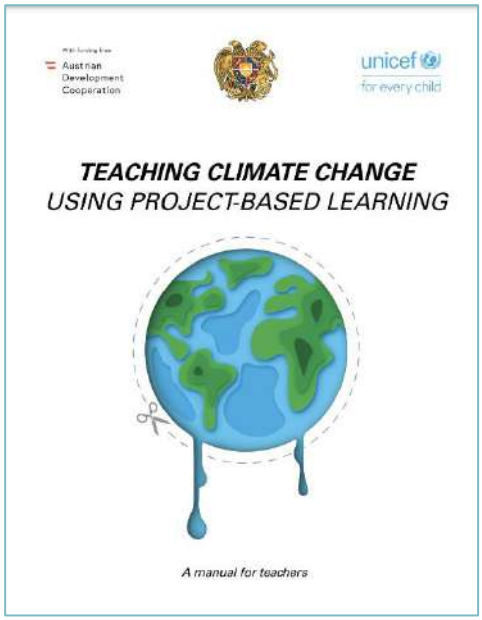
Guide for teachers

Understanding climate change

This comprehensive handbook aims to assist and motivate teachers and students to collaboratively research the climate crisis using a Project-Based Learning approach. It includes a series of lessons with detailed instructions and student worksheets, designed to deepen their understanding of various aspects of climate change and strategies to mitigate the negative effects of human activities.

Link

Guide for teachers



Teaching Climate Change using PBL

The manual is designed for teachers, educators, and those interested in education. The goal is to help educators develop and deliver project-based activities that will enable adolescents and young people to engage and take active participation in applying measures and solutions to mitigate climate change.

Link

Guide for teacher

The emotions of climate change

This resource is a professional development activity primarily for teacher trainers, centered on the emotions individuals may feel in response to climate change, with a specific focus on "eco-anxiety.

Link

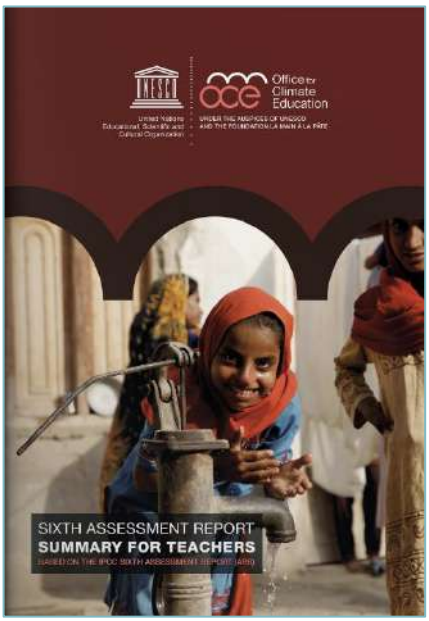
Guide for teachers

Climate Change and critical thinking

This resource is a professional development activity focused on critical thinking, using examples from the field of climate change. Primarily designed for teacher trainers, it employs a card game to enhance critical thinking skills about climate change information. Additionally, it is suitable for engaging students aged 15 to 18.

Link

Guide for teachers



Sixth Assessment Report- Summary for Teachers

The "Summary for Teachers of the IPCC Report AR6" is an essential resource that offers educators the latest information on climate science. This thorough summary is designed to assist in engaging students in meaningful discussions about climate change, its effects, and practical strategies for addressing it.

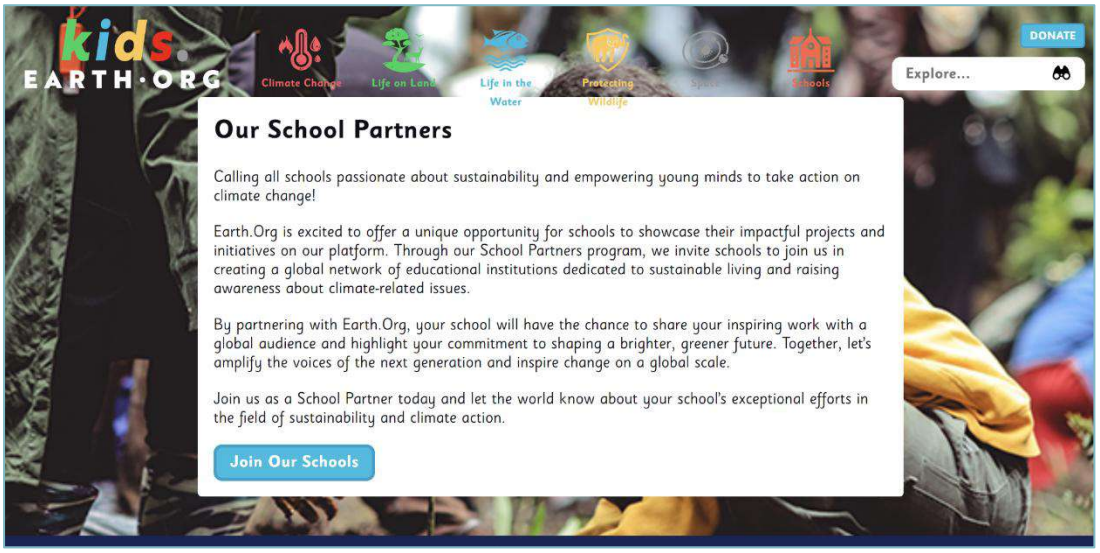
Link

Resource for teachers

Useful platforms and websites

Kids Earth.org

Link: https://kids.earth.org/



Bringing Climate Data to the Classroom

Link: https://climate.copernicus.eu/bringing-climate-data-classroom

Unesco webinar Series for Teachers

Link: https://www.unesco.org/en/sustainable-development/education/cop29-cce-webinars?hub=761

Get in contact

Share Your Climate Education Resources with Us!

Do you have valuable resources, handbooks, or web links related to climate education? We would love to review and include them in the STEAM4CLIMATE handbook, benefiting teachers and students worldwide.

Please send your submissions to: **steam4climate@pw.edu.pl**

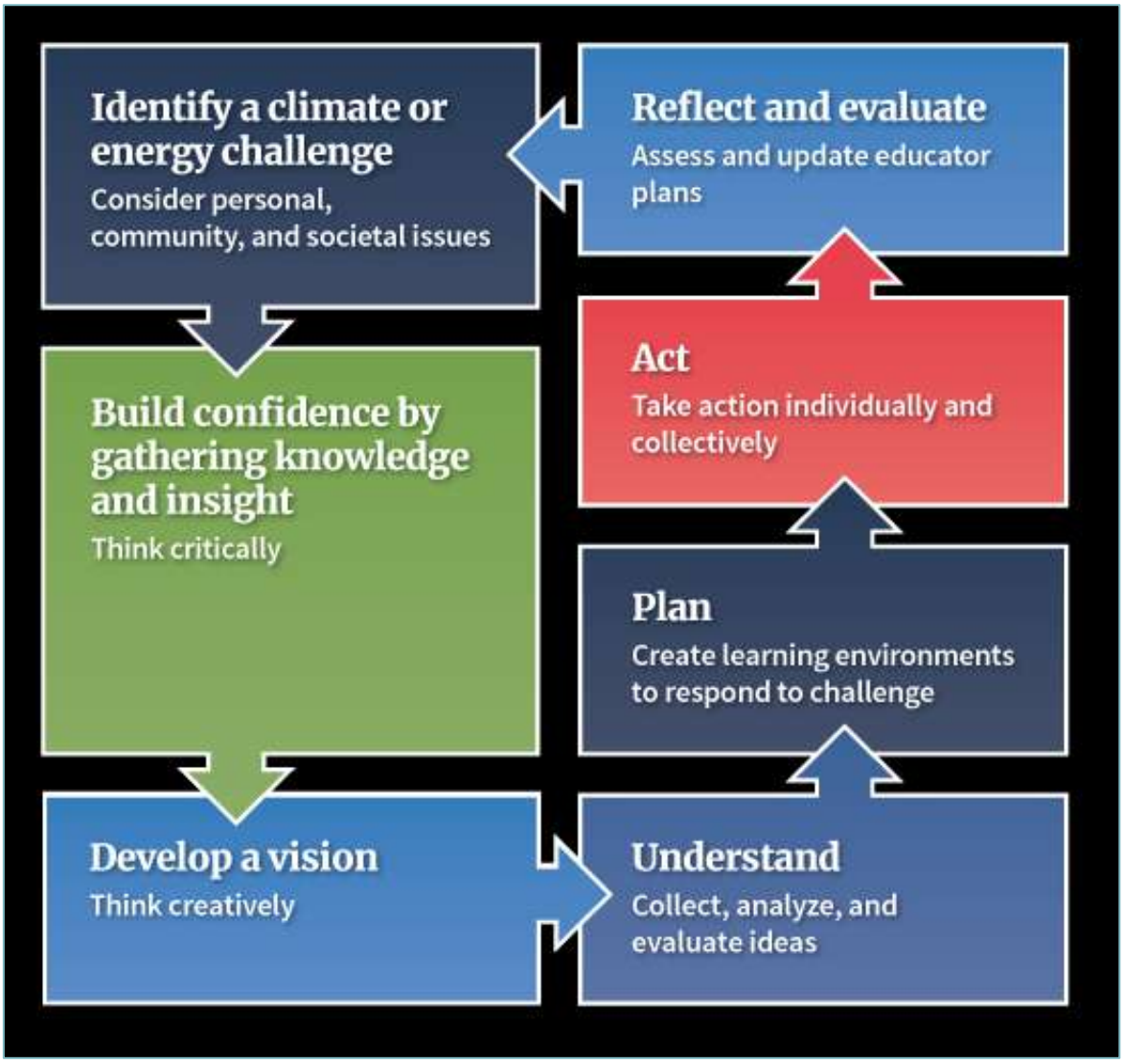
Don't forget to include all necessary reference and copyright details.

Thank you for contributing to a more sustainable future through education!

Appendices

Appendix 1

A note on the methodological decisions underpinning the design of the handbook and the proposed ways for introducing the 5 challenges in the classroom. The handbook and the design of the challenges draws upon the Climate Action Learning process introduced by NOAA Climate.gov.



The 5 challenges are developed and organized along a similar pathway proposed by NOAA Climate.gov, called “the Climate Action Learning Process”. This pathway consists of 7 interlinked steps that progressively introduce and analyze a challenge. The first step is the identification of a climate challenge at a local or global scale, and in the context of environmental and societal issues. The second step is to cultivate critical thinking and build confidence in the topic by gathering useful knowledge and insights. The third step focuses on creative thinking and developing a vision through feasible proposals to mitigate a challenge, which also leads to developing competence in teaching climate change. The fourth step is to build understanding by working across disciplines and collecting, analyzing and evaluating different ideas.The fifth step is to plan by creating a learning environment that meets the real needs of a challenge. This is also done by providing links to authentic and professional resources. The sixth step is about taking action at an individual or collective level. Finally, the seventh step is about reflecting on ideas and actions by sharing, assessing and evaluating their outcomes. This step can be linked to step 1, by reflecting on the issues related to the initial challenge.In this direction, the 5 challenges are developed on a common template addressing all the above mentioned qualities. In particular:

For each challenge, there is a description that introduces the challenge and identifies several key concepts. The description includes references to literature and current research, thus providing scientifically valid content and structured knowledge based on real-world facts. It also highlights methods to mitigate the challenge, paving the way for possible solutions to the problem. In this way, teachers can gain knowledge of all the critical aspects of the challenge and build confidence in introducing the topic to their students in a way that can bolster a sense of hope. The description is followed by learning objectives, a proposed methodology and a series of activities that address different aspects of the challenge, through the lens of different STEAM disciplines. To facilitate their implementation, each activity is enriched with various resources, ranging from links to images, graphics and videos to interviews with experts recorded for the purpose of the handbook. In order to provide further inspiration for teachers, an implementation example is included which presents some of the proposed activities in a hypothetical but possible learning scenario in the classroom. All activities are designed to facilitate discussion among students and encourage the exchange of ideas, while also suggesting ways to incorporate a hands-on approach to learning.

Identification of a Climate Challenge: The learning experience begins with the identification of a local or global climate challenge within the context of environmental and societal issues. This step has been kick-started by the STEAM4Climate team and sets the stage for deeper exploration and understanding.

Cultivate Critical Thinking and Build Confidence: The learners are becoming familiar with the key environmental challenges, gathering and reflecting upon useful knowledge and insights. This help students approach the challenges with confidence and under critical thinking lens.

Creative Thinking and Vision Development: As the learning experience is progressing the students are encouraged to creatively think upon the challenge and ways to mitigate it This step enhances competence in teaching climate change and inspires innovative solutions.

Interdisciplinary Understanding: Work across various disciplines to collect, analyze, and evaluate diverse ideas. This builds a holistic understanding of the challenge and fosters interdisciplinary collaboration.

Planning and Resource Utilization: Create a learning environment that addresses the real needs of the challenge by providing links to authentic and professional resources.

Taking Action: Implement individual or collective actions to address the challenge. This step empowers students to be proactive agents of change.

Reflection and Sharing: Reflect on ideas and actions by sharing, assessing, and evaluating outcomes. This step links back to the initial challenge, ensuring continuous improvement and learning.