# CONTENT




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## 2 TOPIC. STEAM INTEGRATION IN ENVIRONMENTAL EDUCATION

### 2.1. SUBTOPIC. SCIENCE IN ENVIRONMENTAL STUDIES

#### 2.1.1. ACTIVITY PLAN: GREENHOUSE EFFECT MODELING

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| **Introduction part (or activity overview)** | This activity is designed to deepen knowledge about the greenhouse effect. Working in groups, students will create a model of the greenhouse effect, use it to determine the impact of carbon dioxide on environmental temperature, and explain the mechanism of the greenhouse effect. |
| **Setting** | Laboratory |
| **Materials Needed** | Computers, glass covers (aquariums, crystallizers), Petri dishes, thermometers, incandescent lamps, Wurtz flasks, cylindrical separating funnels, rubber hoses, scales, laboratory stands with clamps, soil, distilled water, hydrochloric acid, calcium carbonate, clock. |
| **Learning Outcomes** | • Connect and deepen knowledge about the greenhouse effect acquired in biology, chemistry, and physics classes.<br>• Improve planning and modeling skills.<br>• Develop teamwork skills.<br>• Apply mathematics knowledge in analyzing and presenting work results. |
| **Activity Contents** | **Activity1: Greenhouse Effect Modeling**<br><br>**Theoretical Part (Duration: 25 minutes):** While watching films about the greenhouse effect, students answer the following questions: What is the natural greenhouse effect? What is its significance? Which gases cause climate change? What emits greenhouse gases? After watching the films, the anthropogenic greenhouse effect is discussed, and the predicted consequences of climate change are examined.<br><br>**Videos:**<br><br>https://www.youtube.com/watch?v=XFCdxppTsu0<br><br>https://www.youtube.com/watch?v=Xt1JuroQcmM<br><br>**Task (Duration: 90 minutes):**<br><br>**Step 1:** Students divide into groups. The groups design and create a model of the greenhouse effect.<br><br>**Step 2:** Using the created model, they conduct an experiment to determine the impact of carbon<br>dioxide on air temperature. A control test is performed using a container that is not filled with carbon dioxide gas, and an experimental test is done with carbon dioxide. Temperature changes are recorded for 30 minutes.<br><br>**Step 3:** The research results are presented graphically.<br><br>**Step 4:** Create a diagram of the anthropogenic greenhouse effect in a chosen manner. |

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| | **Step 5:** Present the created model and research results to the class. |
| **Assessments** | After completing the work, students perform self-assessment (Appendix 1). Group work is graded (Appendix 2). |
| **Key Competences** | Cognitive competence<br>Creativity competence<br>Social, emotional and healthy living competences<br>Digital competence |
| **Connections with Eco STEAM** | Eco – Understand the impact of human activity on the climate.<br><br>Science – Connect knowledge of chemistry, physics, and biology.<br>Technology – Skillfully and creatively use digital technologies.<br>Engineering – Create a model of the greenhouse effect.<br>Math – Represent research data graphically. |
| **References** | • https://science.nasa.gov/earth/climate-change/steamy-relationships-how-atmospheric-water-vapor- amplifies-earths-greenhouse-effect/<br>• https://www.nsa.smm.lt/wp-content/uploads/2021/03/2775_Ch-VBE-1-2012.pdf |
| **Notes** | Material for the Teacher<br><br>Students create the greenhouse effect model independently. If groups need teacher assistance, their work can be guided as follows:<br><br>1. Take two Petri dishes. Add an equal amount of black soil to each.<br><br>2. Make thermometer holders. Place the holders with thermometers in the dishes.<br><br>3. Cover the dishes with 1-liter glass covers.<br><br>4. Construct an apparatus to generate carbon dioxide. Secure a cylindrical separating funnel in a laboratory stand. Pour 50 ml of diluted hydrochloric acid (1:2) into it. Connect the cylindrical funnel to a Wurtz flask containing 50 g of calcium carbonate powder. Lead a rubber hose from the flask to one glass cover. Slowly drip the hydrochloric acid into the Wurtz flask, releasing carbon dioxide, which fills one glass cover (Appendix 3).<br><br>5. Place incandescent lamps (75 W) at equal distances from both glass covers.<br><br>6. Record the air temperature inside the glass covers every 5 minutes. Conduct the experiment for 30 minutes. After 30 minutes, the air temperature in the control and experimental covers should differ by 3-4 degrees.<br><br>If materials are limited, first conduct the control experiment, then the experimental one. Carbon dioxide can also be obtained by exhaling several times into the container.<br><br>Other ideas:<br><br>You can investigate the impact of water vapor (water the soil in one container and leave it dry in the other), or the effect of atmosphere (use a glass-covered container and an open glass |

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| | container) on air temperature. |

## APPENDIX 1. SELF-ASSESSMENT SHEET

| Self-Assessment Questions | Answers |
|---|---|
| **What new information did you learn about the greenhouse effect?** | |
| **What skills did you acquire?** | |
| **What did you enjoy?** | |
| **What was difficult?** | |
| **What would you do differently next time?** | |
| **Notes** | |

## APPENDIX 2. EVALUATION SHEET

| Evaluation Criteria | Points | Comments |
|---|---|---|
| **Model** | _/3 | |
| **Graphical Presentation of Results** | _/3 | |
| **Greenhouse Effect Diagram** | _/3 | |
| **Work Presentation** | _/3 | |
| **Independence** | _/3 | |

## APPENDIX 3. GREENHOUSE EFFECT MODEL (FOR INVESTIGATING THE IMPACT OF CARBON DIOXIDE ON AIR TEMPERATURE)

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| 2.1.2. ACTIVITY PLAN: ANALYZING THE IMPACT OF POLLUTION ON ECOSYSTEMS | |
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| **Introduction part (or activity overview)** | This activity encourages students to explore the scientific aspects of pollution and its impacts on various ecosystems. Through detailed research and practical experiments, students will examine the sources, types, and consequences of pollution, and propose scientific methods to mitigate its effects. |
| **Setting** | Location: Classroom equipped with computers, internet access, and appropriate lab equipment for conducting experiments.<br><br>Educational Context: Collaborative group work (2-3 students per group) |
| **Materials Needed** | Computers with internet access<br>Laboratory equipment (e.g., microscopes, test tubes, pH meters)<br>Chemicals for testing water and soil quality<br>Projector and screen for video presentations<br>Access to outdoor areas for sample collection (if possible) |
| **Learning Outcomes** | • Understand the scientific fundamentals of pollution and its ecological impacts.<br>• Apply scientific methods to analyze pollution in local ecosystems.<br>• Develop and propose evidence-based solutions to reduce pollution. |
| **Activity Contents** | **Theoretical Part (Duration: 60 minutes)**: Provide an in-depth look into the science of pollution, including its chemical, biological, and physical dimensions. Discuss various pollutants, their sources, and their effects on air, water, and soil ecosystems. Explore key concepts such as bioaccumulation, eutrophication, and acid rain.<br>• **Key Concepts Covered**:<br>  o Types of pollutants (organic, inorganic, biological, radiological)<br>  o Mechanisms of pollution dispersion in different environments<br>  o Long-term versus short-term ecological impacts of pollution<br>• **Video Resources**:<br>  o "Science Behind Pollution" |

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| | (https://www.youtube.com/watch?v=exampleLink1) – Explains the chemical and biological processes that underpin pollution dynamics.<br>o "Pollution and Ecosystems" (https://www.youtube.com/watch?v=exampleLink2) – Discusses how various pollutants impact ecosystems globally.<br>**Task 1: Ecosystem Pollution Analysis (Duration: 80 minutes)**<br>**Step 1**: Students select an ecosystem type (e.g., freshwater, marine, terrestrial) and research the common pollutants affecting these environments. Utilize scientific databases and journals to gather current data and studies.<br>**Step 2**: Conduct a virtual or real-life case study to assess the pollution levels. This may involve:<br>● Collecting water or soil samples and analyzing them for specific contaminants.<br>● Using simulation software to model pollution dispersion and its ecological impacts.<br>**Step 3**: Compile a scientific report that includes:<br>● A detailed description of the chosen ecosystem and prevalent pollutants.<br>● Data from their analyses and interpretations of how these pollutants impact the ecosystem.<br>● Visual aids like charts, graphs, and maps to illustrate findings.<br>**Step 4**: Present the findings to the class, focusing on scientific accuracy and clarity in communication.<br><br>**Task 2: Developing Pollution Mitigation Strategies (Duration: 70 minutes)**<br><br>**Step 1**: Based on their research and findings from Task 1, students brainstorm potential solutions to mitigate the identified pollution issues.<br>**Step 2**: Design a detailed action plan that includes:<br>● Specific scientific methods and technologies to reduce or eliminate pollutants.<br>● A feasibility analysis of proposed solutions, considering technical, economic, and social factors.<br>● A campaign plan to raise awareness about pollution and promote community engagement in mitigation efforts.<br>**Step 3**: Each group pitches their mitigation strategy to the class, simulating a proposal to local environmental agencies or community stakeholders. |
| **Assessments** | Depth and scientific rigor of ecosystem analysis.<br>Innovative approaches and practicality of mitigation strategies.<br>Effectiveness of communication and engagement during presentations. |
| **Key Competences** | Scientific literacy in environmental science<br>Analytical and problem-solving skills<br>Communication and teamwork<br>Civic responsibility and environmental stewardship |
| **Connections with Eco STEAM** | Eco Science: Core focus on scientific inquiry and methodologies.<br><br>Technology: Use of lab technology and data analysis tools.<br>Engineering: Application of engineering solutions to pollution control. |

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| | Arts: Creative presentation and visualization of scientific data.<br>Math: Statistical analysis of pollution data and effectiveness of solutions. |
| **References** | www.journalofenvironmentalpollution.com |
| **Notes** | This activity may extend to an ongoing project, allowing students to monitor their proposed solutions and their impact over time. |

**Evaluation Table for Analyzing the Impact of Pollution on Ecosystems Activity**

| Evaluation Criteria | Points Available | Comments |
|---|---|---|
| **1. Depth of Scientific Research** | 20 | Evaluate the thoroughness and depth of the scientific research conducted on pollution and its impacts. |
| **2. Accuracy of Scientific Data** | 20 | Assess the accuracy and relevance of the scientific data and interpretations presented in the reports. |
| **3. Innovation in Solution Design** | 15 | Rate the creativity and feasibility of the pollution mitigation strategies proposed by the students. |
| **4. Quality of Experimental Methods** | 15 | Evaluate the appropriateness and execution of experimental methods used to analyze pollution in ecosystems. |
| **5. Clarity and Organization of Presentation** | 10 | Assess how effectively the group presented their findings and proposals, including the use of visual aids. |
| **6. Engagement and Interaction** | 10 | Rate the group's ability to engage and interact with the audience during their presentation, including handling questions effectively. |
| **7. Team Collaboration** | 10 | Evaluate the effectiveness of teamwork and collaboration within the group throughout the project duration. |

**Total Points:** 100

## 2.1.3. ACTIVITY PLAN: EFFECT OF OCEAN ACIDITY ON MARINE ANIMALS

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| **Introduction part (or activity overview)** | This educative experiment is aimed to raise awareness about the devastating effects of ocean acidification on shelled marine organisms.<br>The burning of fossil fuels leads to an increase in carbon dioxide in the environment. The increased levels of carbon dioxide in the air causes more carbon dioxide to dissolve in the ocean which in<br>turn leads to an increase in the acidity of the ocean. This is termed ocean acidification and some of the effects of this devastating phenomena are represented through this experiment. |

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| **Setting** | A lab/ chemistry classroom - Instead of using a jar, you can use a beaker. It is important to seal the beaker to prevent any potential spills.<br>At home - If you do not have any vinegar, use your science brain to locate other acidic food items present at your home. You might want to use lemon juice or even ketchup instead. |
| **Materials Needed** | 3 eggs, 3 jam jars, Stretch and seal, Water, Vinegar, Bleach |
| **Learning Outcomes** | The main goal of this experiment is to show the devastating effects of ocean acidification on marine animals possessing a calcium carbonate shell.<br>Another objective is to show what happens to the eggshell when placed in acidic and basic environments and to relate the results to what would happen to a shelled marine organism. |
| **Activity Contents** | **Activity 1: Ocean acidification and its impact on marine organisms (Duration: 15 minutes)**<br>**Theoretical part:**<br>**The teacher gives them directions and links regarding the experiment:**<br><br>http://news.nationalgeographic.com/news/2014/05/140502-ocean-snail-shell-dissolving-acidification- climate-change-science/<br>https://www3.epa.gov/climatechange/kids/impacts/signs/acidity.html<br>Students read about an experiment: shell placed in vinegar solution is no longer present after the experiment was performed. This is an acid-base reaction:<br>acetic acid (vinegar) + calcium carbonate (eggshell) → calcium acetate + carbon dioxide + water<br><br>Ocean acidification occurs when an increase in the level of carbon dioxide in the air forces more carbon dioxide to dissolve in the water. Carbon dioxide reacts with water to form carbonic acid which leads to a lowering of pH i.e. increase in acidity. This in turn causes the shells of marine organisms to dissolve.<br>$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+$<br><br>**Activity 2: Realization of an experiment**<br>**(Duration: 80 minutes)**<br>**The teacher introduces the students to the steps of experiment.**<br>Step 1: Place 50 mL of vinegar in a jar together with 100 mL of water. Label this jar as acidic.<br>Step 2: Place 50 mL of bleach in a jar together with 100 mL of water. Label this jar as basic.<br>Step 3: Place 150 mL of water in a jar and label this as neutral.<br>Step 4: Place an egg in each of the jars and seal them with either a lid or with stretch and seal.<br>Step 5: Leave for 24 hours and observe any differences on the egg.<br>Step 6: If nothing happens, repeat steps 1-5 but this time using constantly the same eggs.<br>Step 7: Finally, remove the eggs and see what has happened to the eggshells.<br>Students carry out the experiment, using the steps given by the teacher,<br><br>**Activity 3: Discussion (Duration: 60 minutes)**<br><br>The teacher discusses and analyzes connected topics: ocean acidification, ocean acidity, coral reef ecosystems, calcium carbonate, hydrogen ions, carbon dioxide in the atmosphere. |

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| | Students discuss what they witnessed, what they produced, and how it was achieved. They share possible solutions to environmental issues, analyse sustainability in terms of lower/ stop ocean acidification.<br><br>**Example questions (reflection):**<br>**What is ocean acidification?** Increase in the acidity of the ocean causing a decrease in pH.<br>**Why were eggshells used?** To represent the calcium carbonate shells of marine organisms.<br>**Why was vinegar used?** To show the effects of acid on calcium carbonate.<br>**Why were bubbles produced in the vinegar solution?** Carbon dioxide<br>**What causes ocean acidification?** Increase in atmospheric carbon dioxide levels.<br><br>**Activity 4 – Research related to the experiment (Duration: 30 minutes)**<br>Students look at some research and EU funded projects connected with the topic:<br>**http://ec.europa.eu/environment/integration/research/newsalert/pdf/ocean_acidification_puts_norwe gian_fishing_industry_at_risk_486na2_en.pdf**<br>**http://cordis.europa.eu/project/rcn/209836_en.html**<br>**http://cordis.europa.eu/result/rcn/161225_en.html**<br>**http://cordis.europa.eu/project/rcn/100200_en.html**<br><br>**Additional tips**<br>Investigate the action of other household items on the eggshell. Use your science knowledge to observe what substances are more acidic than others.<br>If you happen to be next to a beach, collect some seashells and this time perform the experiment using actual seashells. See if the results compare to what happened to the eggshell.<br>Make the experiment a little bit more fun by attaching a balloon to the neck of a conical flask where the shells with the vinegar are placed and see what happens to the balloon. The balloon should inflate since the decomposition of calcium carbonate present in the eggshell leads to the generation of carbon dioxide gas. |
| **Assessments** | The final result is evaluated with a grade.<br>All students in the class can be included in the evaluation.<br>Each student independently evaluates his contribution to the work.<br>Students can compete in the best-performed experiment.<br>The assessment takes into account: student engagement, egg shape, description, costing and conclusions. |
| **Key Competences** | • Cognitive competence<br>• Creativity competence<br>• Communication competence<br>• Social, emotional and healthy living competences<br>• Citizenship competence<br>• Digital competence<br>• Cultural competence |

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| **Connections with Eco STEAM** | Eco - using natural materials, from the kitchen.<br>Science - knowledge of chemistry, biology and physics; environmental sciences - fostering sustainability thinking.<br>Technology - using a computer in the research process.<br>Engineering - carbon dioxide production.<br>Art - creating visual representations of the impact of ocean acidification on marine life.<br>Math - using mathematical concepts to analyze the results of an experiment. |
| **References** | http://news.nationalgeographic.com/news/2014/05/140502-ocean-snail-shell-dissolving-acidification- climate-change-science/<br>https://www3.epa.gov/climatechange/kids/impacts/signs/acidity.html<br>http://ec.europa.eu/environment/integration/research/newsalert/pdf/ocean_acidification_puts_norwegia n_fishing_industry_at_risk_486na2_en.pdf<br>http://cordis.europa.eu/project/rcn/209836_en.html<br>http://cordis.europa.eu/result/rcn/161225_en.html<br>http://cordis.europa.eu/project/rcn/100200_en.html |
| **Notes** | This experiment can be messy, hence it is ideal to place the jars on a tray so that any spillages can be contained. It is also ideal to keep hand towels close by.<br><br>Some children can be allergic to eggs, therefore be careful if any weird behaviour is observed during/after the experiment.<br><br>Bleach is very dangerous therefore it is ideal that it is only handled by the demonstrators. To show the importance of lab safety it is ideal to advise the children to wear lab coats, safety goggles and gloves while performing the experiment. |

**Assessment Table for individual work:**

| Evaluation Criteria | Points | Comments |
|---|---|---|
| | | |
| Understanding the concept of acidification of the oceans | _/5 | |
| Understanding the process of osmosis | _/5 | |
| Communication competence | _/5 | |
| Cognitive competence | _/5 | |
| Competence for creativity | _/5 | |
| Answered questions correctly | _/10 | |
| Completed homework | _/10 | |

**Assessment Table for group work:**

| **Assessment Criteria** | **Points** | **Comments** |
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| Internet research skills | _/5 | |
| Changing the shell of an egg | _/10 | |
| Calculation of cost price | _/5 | |
| Ecological Interpretations in the project | _/5 | |
| Teamwork and Collaboration | _/5 | |
| Skills of presenting the work | _/5 | |

| **2.1.4. ACTIVITY PLAN: FAIRY HAND** | |
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| **Introduction part (or activity overview)** | This experiment is aimed at creating fire bubbles using water, detergent and flammable gas. By mixing the ingredients and their interaction, flammable balloons are formed that release energy in the form of heat and light. When gas burns, it creates a controlled flame. Students combine these elements to prove the chemical reaction. Fire bubbles effectively demonstrate how combustion can generate pollutants. The experiment produced a strong flame and effectively illustrated the biochemical aspects of combustion-induced pollution. |
| **Setting** | A chemical cabinet with appropriate equipment for conducting bio-chemical processes or a classroom with the necessary equipment and materials.<br>Educational context: teamwork and learning. |
| **Materials Needed** | Glass container with water, liquid soap, flammable gas, lighter. |
| **Learning Outcomes** | • Encourage local environmental challenges and solutions.<br>• Reinforce the awareness that everyone can contribute to environmental sustainability.<br>• Develop teamwork and environmental conservation skills.<br>• Enhance research skills for global and local perspectives in environmental education. |
| **Activity Contents** | **Activity 1: Preparation for an experiment**<br>**Theoretical part (Duration: 15 minutes): Discussion of the combustion process and the products of the combustion process**<br>• Discussion about air pollutants, finding ways to purify the air by reducing all pollutants, including the combustion process.<br>• Students research on the internet about the combustion process and all the negative consequences of the combustion products, depending on the combustion reactants.<br>**Task (Duration: 90 minutes):**<br>Step 1: Working in groups. Each group to prepare laboratory equipment and reagents for experimentation. |

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| | Step 2: Have each group state a hypothesis and expected results of the experiment.<br>Step 3: Giving suggestions on how to reduce air pollutants.<br><br>**Activity 2: Demonstration of an experiment**<br><br>**Theoretical part (Duration: 20 minutes):** Watching and discussing a video of a fairy hand, description of the experiment and method of performance.<br><br>Duration: Approx. 1 minute<br><br>https://www.youtube.com/watch?v=bRm4POS7Rv4<br><br>Processes description: Some liquid soap is poured into a glass container with water. The solution is stirred. A flammable gas is passed through the solution. After dipping a hand in the solution, the experimenter collects some foam in the palm of the same hand and ignites it. The foam burns without burning the experimenter's hand!<br><br>**Task 1 (Duration: 60 minutes): Demonstration of an experiment**<br>Step 1: Prepare the mixture, combine water, flammable gas and soap. The soap helps create bubbles that will be placed on the demonstrator's hands.<br>Step 2: Ignite the mixture, causing the flammable gas to burn, which creates a controlled flame in the container.<br>Step 3: Cover the hands of the demonstrator with soap bubbles containing water from the mixture.<br>Step 4: Demonstrate the Leidenfrost effect: With soap bubbles covering your hands, insert them into the container with the burning gas mixture. As the soap bubbles come into contact with the hot gas, the water in the bubbles evaporates, creating a protective layer of steam around the person's hands. The vapor layer insulates the person's hands from direct contact with the burning gas, preventing them from burning.<br>Step 5: Watch the soap bubbles break up around the person's hands as they dip them into the container, demonstrating the protective effect of the Leidenfrost effect.<br><br>**Task 2 (Duration: 30 minutes):** Final Work. Reflection. Students answer questions about endothermic and exothermic reactions, discuss the reason why the flame from this experiment does not cause burns, draw a poster on this topic.<br><br>Reactions that absorb heat are called "endothermic reactions," while reactions that release heat are referred to as "exothermic reactions." For example, combustion is an exothermic process, which is why we feel heat emanating from fire. Meanwhile, water evaporating or ice melting are examples of endothermic processes. This experiment involves both types of reactions – when the flammable gas in the foam burns, a large amount of heat is released, which is immediately spent on evaporating the water covering the hand. As a result, the fire does not burn the hand! |
| **Assessments** | The reflection will be evaluated through the self-evaluation method.<br>The evaluation segments are contained in the evaluation table, which includes: proper handling of laboratory equipment and reagents, drawing poster, description of the |

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| | process, skills in presenting about Science in Environmental Studies. All students in the class can be included in the evaluation. |
| **Key Competences** | • Cognitive competence<br>• Creativity competence<br>• Communication competence<br>• Social, emotional and healthy living competences<br>• Digital competence |
| **Connections with Eco STEAM** | Eco - improvement of air quality by reducing air pollutants.<br><br>Science – demonstration of the combustion process.<br>Technology – creative use of information technology.<br>Engineering – developing a model for improving the quality of the air.<br>Art – develop skills in the art of visualization, drawing posters.<br>Math – mathematical calculations when making a solution. |
| **References** | https://www.youtube.com/watch?v=bRm4POS7Rv4 |
| **Notes** | In order to control air pollution, it is necessary to take measures to reduce the emission of polluting gases and particles. This implies legal and technological measures such as the establishment of national and international legal provisions to reduce emissions. A monitoring system is also important to assess air quality and detect important changes. The main permanently monitored air pollutants are frequent, such as CO2, O3 and pollen in the air. Physical contamination - one of the most serious health risks associated with air pollution is the presence of particulate matter in suspension. The most dangerous are those with a diameter of less than 10 µm (0.01 mm), these particles can penetrate deep into the alveoli of the lungs and often consist of hydrocarbons and toxic metals. Particulate matter (PM) - These material particles are also emitted into the environment by combustion processes, such as aerosol applications and various erosive industrial processes. Internal combustion engines (especially diesel) and solid fuel combustion (especially coal) are two of the most important sources of particulate matter.<br><br>It is also necessary to reduce dependence on fossil fuels and increase the use of clean energy (hydroelectric, solar, wind, geothermal). It is essential to raise public awareness about the causes,consequences and preventive measures against air pollution. |
| Visually compelling experiment “Fairy hand “ | |

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## PERFORMANCE OF THE EXPERIMENT BY OUR STUDENTS

**Activity 2 Self-Assessment Table**

| Evaluation criteria | Points | Comments |
|---|---|---|
| Proper handling of laboratory equipment and reagents | _/5 | |
| **Effectiveness of planning**<br><br>**Proving the set hypothesis** | _/5 | |
| Writing combustion process equation and making poster | _/5 | |
| **Ability to act according to the plan**<br><br>Description of burning process and products of burning | _/5 | |
| **Creativity Collaboration Effort**<br><br>Skills in presenting about Environmental Studies | _/5 | |
| **What worked** | | |
| What needs to be improved | | |

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| 2.1.5. ACTIVITY PLAN: THE ROLE OF SCIENCE IN UNDERSTANDING AND SOLVING ENVIRONMENTAL CHALLENGES | |
|---|---|
| **Introduction part (or activity overview)** | This activity is designed to highlight the integral role of scientific inquiry and methodologies in addressing environmental issues. Students will explore how scientific principles are applied to understand and solve real-world environmental problems, focusing on areas such as climate change, biodiversity, and pollution. |
| **Setting** | Location: Classroom equipped with computers, internet access, and multimedia capabilities.<br><br>Educational Context: Collaborative group work (2-3 students per group). |
| **Materials Needed** | Computers with internet access<br>Projector and screen for video presentations<br>Scientific journals and online databases for research<br>Lab equipment for small-scale experiments (optional) |
| **Learning Outcomes** | • Develop a deep understanding of the scientific methods used in environmental studies.<br>• Apply scientific principles to analyze and propose solutions to environmental problems.<br>• Enhance communication and teamwork skills through collaborative research and presentations. |
| **Activity Contents** | **Theoretical Part (Duration: 60 minutes)**: Start with an in-depth exploration of how science underpins environmental education. Discuss key scientific disciplines such as ecology, environmental chemistry, and geology, and their roles in understanding the environment.<br>• **Key Concepts Covered**:<br>  o The scientific method and its application in environmental research.<br>  o How ecological studies help in understanding biodiversity and ecosystem services.<br>  o The role of environmental chemistry in assessing pollution and its impacts.<br>• **Video Resources**:<br>  o "Science in Environmental Decision-Making" (https://www.youtube.com/watch?v=exampleLink1) – Explains how scientific data informs policies and decisions in environmental management.<br>  o "Interdisciplinary Science in Solving Environmental Problems" (https://www.youtube.com/watch?v=exampleLink2) – Showcases examples of how various scientific disciplines collaborate to address complex environmental issues.<br>**Task 1: Scientific Analysis of an Environmental Issue (Duration: 70 minutes) Step 1**: Each group selects an environmental issue such as air pollution, water quality, or loss of biodiversity. They research the issue using scientific databases and journals to gather relevant data and studies.<br>**Step 2**: Prepare a detailed report that includes:<br>• A description of the environmental issue, backed by scientific data.<br>• Analysis of the factors contributing to the issue using scientific principles.<br>• Review of current scientific approaches being used to address the issue. **Step 3**: |

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| | Present their findings in a well-organized presentation, using visuals like graphs, charts, and maps to support their data.<br>**Task 2: Designing a Scientific Experiment or Study (Duration: 60 minutes) Step 1**: Based on their earlier research, each group designs a small-scale scientific experiment or observational study that could provide further insights into the environmental issue they are studying.<br>**Step 2**: Outline the experiment/study proposal that includes:<br>● Hypothesis or research questions.<br>● Methodology: detailing the experimental setup or observational techniques.<br>● Expected outcomes and how they will contribute to solving the environmental issue.<br>● Considerations of ethical and practical implications.<br>**Step 3**: Each group pitches their experimental design to the class, receiving feedback on the feasibility and scientific rigor of their proposed methods. |
| **Assessments** | Depth and accuracy of scientific research.<br>Innovation and feasibility of the experimental design.<br>Clarity, coherence, and scientific accuracy in presentations. Active participation and teamwork. |
| **Key Competences** | Scientific literacy and critical thinking<br>Research and data analysis skills<br>Problem-solving and experimental design<br>Effective communication and collaborative learning |
| **Connections with Eco STEAM** | Eco Science: Core focus on using scientific inquiry to understand and address environmental issues.<br><br>Technology: Utilizing modern technology for data collection and analysis.<br>Engineering: Applying engineering principles in experimental setup and solution development.<br>Arts: Employing creative approaches to present scientific data effectively.<br>Math: Using statistics and mathematical models to interpret data and predict outcomes. |
| **References** | www.journalofenvironmentalsciences.com |
| **Notes** | Extend this activity into a project-based learning module, where students can actually conduct their proposed experiments if feasible. |

**Evaluation Table for Science in Environmental Studies Activity**

| Evaluation Criteria | Points Available | Comments |
|---|---|---|
| **1. Depth of Scientific Research** | 20 | Evaluate the thoroughness and depth of the scientific research conducted on the selected environmental issue. |
| **2. Accuracy of Scientific Data** | 15 | Assess the accuracy and relevance of the scientific data presented in the reports. |
| **3. Innovation in Experimental Design** | 15 | Rate the creativity and innovation in the design of the proposed |

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| | | experiment or study. |
| **4. Methodology Clarity** | 15 | Judge how clearly the experimental or study methodology is planned and presented. |
| **5. Analysis and Interpretation** | 15 | Evaluate the rigour and depth of the analysis and interpretation of data in their reports and presentations. |
| **6. Presentation Skills** | 10 | Assess the effectiveness of the presentation in terms of clarity, organisation, and use of visual aids. |
| **7. Team Collaboration** | 10 | Rate the level of effective collaboration and contribution from all team members throughout the project. |

**Total Points:** 100

## 2.2. SUBTOPIC. TECHNOLOGY FOR ENVIRONMENTAL SOLUTIONS

| **2.2.1. ACTIVITY PLAN: MAKING SOLAR OVENS** | |
|---|---|
| **Introduction part (or activity overview)** | During these activities, students will practically construct solar cookers where solar energy will be used for sustainable food preparation. Collaborating in designing and experimenting, they will delve into renewable energy and its practical application. By testing and refining their prototypes, students will develop problem-solving skills and creative thinking abilities. This project aims to inspire students to seek innovative solutions for environmental sustainability while encouraging a deeper understanding of the potential of solar energy. |
| **Setting** | Classroom.<br>Sunny place outside |
| **Materials Needed** | • Cardboard box / two boxes that can fit into each other / pizza box / cardboard pieces<br>• Aluminum foil / used packaging with foil<br>• Transparent plastic film / glass sheet<br>• Black construction paper / spray-on black paint<br>• Insulating materials (newspaper, polystyrene)<br>• Scissors<br>• Measuring tape / ruler<br>• Pencil<br>• Thermometer / temperature sensor<br>• Glue, adhesive tape |
| **Learning Outcomes** | • Expand knowledge about solar energy utilization<br>• Deepen fundamental engineering and design skills in creating solar cookers.<br>• Enhance problem-solving and critical thinking skills by addressing issues, adjusting designs, and optimizing the performance of solar cookers.<br>• Improve knowledge related to heat transfer, insulation, and solar energy reflection.<br>• Enhance teamwork and communication skills.<br>• Promote environmental awareness and sustainability, emphasizing the use of renewable energy sources. |
| **Activity Contents** | **Activity1: Making solar ovens.**<br>**Theoretical part (Duration: 15 minutes):** Remembering that solar energy obtained from sunlight is a clean and renewable energy source that helps address environmental issues |

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| | and reduces dependence on fossil fuels. Students know that solar energy can be used to generate electricity in solar panels, but few have heard of solar ovens. These devices use solar heat to prepare food, eliminating the need for traditional cooking methods that rely on non-renewable energy sources such as gas or electricity. Solar ovens capture solar energy through reflective surfaces and convert it into thermal energy, making them an eco-friendly alternative that adheres to sustainability principles. Such ovens are an excellent alternative to burning wood when camping or vacationing where there are no other energy sources.<br>**Videos:**<br>https://www.youtube.com/watch?v=dAUF5fp35Ys<br>Overview: This video shows how does a Sun Cook solar oven work.<br>Duration: Approx.1.5 minutes<br><br>https://www.youtube.com/watch?v=Ofn7jqPDTeY<br>Overview: This video shows how a stove powered by the sun is making a big difference in impoverished countries.<br>Duration: Approx.3.10 minutes<br><br>https://www.youtube.com/watch?v=DhhXGF8hE20<br>Overview: This video explains how to make and use a solar cooker. Duration: Approx.6.5 minutes<br><br>**Task 1: Design Stage (30 minutes):** Divide the students into groups (4-6 students each) and ask them to brainstorm and draw their solar cooker design. Encourage creativity while ensuring that their designs are practical and feasible, considering factors such as size, shape, insulation, and reflectivity. Students should decide what tools and materials they will need for building the cooker. The construction should take place the next day, as students need time to gather materials unless provided by the teacher.<br><br>**Task 2: Construction (45 minutes):** Students build their solar cookers based on their designs.<br><br>**Task 3: Testing and Cooking Demonstration (60 minutes):** This task is conducted outdoors on a sunny day. Each group must place their solar cooker in direct sunlight. Insert a thermometer into the cooker and regularly measure the temperature. Once the solar cookers reach the appropriate temperature, begin cooking a small dish (e.g., s'mores, hot dogs, vegetables).<br><br>**Task 4: Presentation of Work (30 minutes):** Students present their created and tested solar cookers. They should evaluate the structure, explain how they work, assess their efficiency, identify what worked well, and suggest improvements. Students discuss their learning experience, challenges faced, and new insights gained about solar energy and sustainable living. |
| **Assessments** | The final result is assessed according to the grading table No. 1. |
| **Key Competences** | Cognitive competence<br>Creativity competence<br>Communication competence<br>Digital competence<br>Citizenship competence |

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| **Connections with Eco STEAM** | **Eco –** Implementation of eco-friendly practices using renewable solar energy.<br><br>Science – Physics knowledge: heat transfer, thermal conductivity, and properties of light.<br>Technology – Solar ovens are a simple yet effective technology that harnesses solar light to generate heat for cooking.<br>Engineering – Applies engineering principles: problem-solving, design of structures, material selection, testing.<br>Art – The design and decoration of solar ovens allow for artistic expression.<br>Math – Performs mathematical calculations in designing solar ovens, measuring, and cutting materials. |
| **References** | https://www.youtube.com/watch?v=yJIQCDnVNrE How to Build a Solar Oven?<br>https://www.youtube.com/watch?v=DaiGiRqCTQw&t=459s How to Build a Solar Cooker?<br>https://www.youtube.com/watch?v=nUX9nEIOSrU Solar Cooking and Food Physics with Carla Ramsdell, Physics and Astronomy, CAS Zoomer Fall 2020<br>https://www.youtube.com/watch?v=t97JyTMEOd0 How to Make a Solar Oven? |
| **Notes** | |

Evaluation Table No. 1

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Design and Construction** | _/5 | Is the design of the solar oven well thought out and structurally reliable?<br>Are suitable materials used for insulation and reflection? Are safety aspects such as stability and heat insulation taken<br>into account in the design process? |
| **Functionality** | _/5 | Does the solar oven effectively harness sunlight to generate enough heat?<br>Is the baking chamber adequately insulated to retain heat?<br>Does the solar oven operate consistently and reliably during testing? |
| **Innovation and Creativity** | _/5 | Does the solar oven demonstrate originality and creativity in<br>its design and construction? |
| | | Are there unique features or adaptations that enhance functionality or aesthetics? |

| **2.2.2. ACTIVITY PLAN: APPLYING TECHNOLOGY FOR ENVIRONMENTAL INNOVATION** | |
|---|---|
| **Introduction part (or activity overview)** | This activity focuses on leveraging technology to develop innovative solutions to environmental<br>problems. Students will explore various technological tools and applications, work |

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| | collaboratively to design a tech-driven environmental solution, and present their findings. |
| **Setting** | Location: Classroom and computer lab for research and development.<br><br>Educational Context: Collaborative group work (4-5 students per group). |
| **Materials Needed** | Computers with internet access and relevant software (e.g., environmental modeling tools, GIS) Digital cameras or smartphones<br>Access to online research databases<br>Projector for presentations<br>Materials for creating digital models or prototypes (optional) |
| **Learning Outcomes** | ● Understand the role of technology in solving environmental problems.<br>● Develop practical skills in using technological tools for environmental analysis and innovation.<br>● Enhance abilities in research, project development, and presentation. |
| **Activity Contents** | **Theoretical Part (Duration: 45 minutes)**:<br>Begin with an introduction to the significance of technology in addressing environmental issues. Highlight various technologies that can be applied to environmental conservation and sustainability.<br>● **Introduction to Environmental Technologies**:<br>o Discuss technologies such as Geographic Information Systems (GIS), remote sensing, environmental modeling software, and renewable energy technologies.<br>o Explore case studies where technology has successfully addressed environmental challenges.<br>● **Video Resources**:<br>o "Environmental Protection Technology" https://www.youtube.com/watch?v=dJoIp5P_yo8 – A video showcasing different technologies used in environmental protection and conservation.<br>o "EU Environmental Technology Verification for green innovations explained " https://www.youtube.com/watch?v=JiNDM5jOJI8 – An overview of cutting-edge technologies in environmental science and their applications.<br>**Task 1: Research and Brainstorming Session (Duration: 45 minutes) Objective**: To identify environmental problems that can be addressed using technology and brainstorm potential solutions.<br>● **Step 1**: Form groups and assign each group a broad environmental issue to focus on (e.g., air pollution, water quality, waste management).<br>● **Step 2**: Conduct online research to identify specific problems within the assigned issue that can be addressed using technology.<br>● **Step 3**: Brainstorm potential technological solutions, considering feasibility, innovation, and sustainability.<br>● **Step 4**: Each group selects one solution to develop further.<br>**Task 2: Project Development and Design (Duration: 90 minutes) Objective**: To develop a detailed project plan for the selected technological |

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| | solution.<br>• **Step 1**: Develop a detailed project plan that includes:<br>  o Problem definition and objective<br>  o Technological approach and tools required<br>  o Implementation steps and timeline<br>  o Expected outcomes and sustainability considerations<br>• **Step 2**: Create a digital model or prototype of the proposed solution using relevant software or tools (optional but encouraged).<br>• **Step 3**: Prepare a presentation summarizing the project plan, technological approach, and expected impact.<br>**Task 3: Presentation and Feedback (Duration: 45 minutes) Objective**: To present the project to the class and receive feedback.<br>• **Step 1**: Each group presents their project plan and digital model or prototype to the class.<br>• **Step 2**: Conduct a Q&A session where other students and the instructor can provide feedback and ask challenging questions.<br>• **Step 3**: Groups reflect on the feedback received and discuss potential improvements. |
| **Assessments** | Innovation and creativity in solution development.<br>Quality and feasibility of the project plan.<br>Effectiveness in using technology for environmental solutions.<br>Clarity and persuasiveness of the presentation.<br>Team collaboration and dynamics. |
| **Key Competences** | Research and analytical skills<br>Technological proficiency in environmental applications<br>Strategic planning and project management<br>Effective communication and presentation skills<br>Teamwork and collaboration |
| **Connections with Eco STEAM** | Eco: Understanding and addressing environmental issues through technological solutions.<br><br>Science: Applying scientific principles to analyze and solve environmental problems.<br>Technology: Utilizing digital tools and software for environmental research and innovation.<br>Engineering: Designing practical solutions and prototypes to address environmental challenges. Arts: Creating engaging presentations and visualizations to communicate findings.<br>Math: Using data analysis and modeling to support technological solutions. |
| **References** | www.environmentalinnovation.org |
| **Notes** | This activity can be extended into a longer-term project, where students continuously develop and refine their technological solutions based on ongoing research and feedback. |
| **Evaluation Criteria Table for Applying Technology for Environmental Innovation Activity** | |

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| Evaluation Criteria | Points Available | Comments |
|---|---|---|
| **1. Innovation and Creativity in Solution Development** | 20 | Assess the originality and creativity of the proposed technological solution to the environmental issue. |
| **2. Quality and Feasibility of the Project Plan** | 20 | Evaluate the thoroughness and feasibility of the project plan, including objectives, methods, and expected outcomes. |
| **3. Technological Proficiency** | 20 | Rate the effectiveness and proficiency in using technology to deve the solution. |
| **4. Clarity and Persuasiveness of Presentation** | 20 | Rate the clarity, persuasiveness, and professionalism of the presentation. |
| **5. Team Collaboration and Dynamics** | 20 | Assess the level of teamwork, including communication, cooperati and mutual support among team members. |

**Total Points:** 100

| **2.2.3. ACTIVITY PLAN: APPLYING TECHNOLOGY FOR ENVIRONMENTAL INNOVATION** | |
|---|---|
| **Introduction part (or activity overview)** | Through this activity the students will acquire the following competencies:<br><br>Students engage in environmental education and hands-on creativity.<br>Create positive relationship with the environment.<br>Develop a sense of place and a curiosity of nature.<br><br>Also, students are empowered to promote environmental stewardship, biodiversity, and educational opportunities for the entire school community. |
| **Setting** | Classroom and outdoor work in a school yard, complemented by digital research. |
| **Materials Needed** | Drawing paper or poster boards; markers, colored pencils, digital drawing tools; rulers, compasses, and other drawing instruments; reference materials (e.g., books, websites, photographs) of gardens and plants; information about local plant species, climate considerations and gardening techniques; poster boards or large paper for final presentations; projector or screen (if presenting digital designs); seeds or plant catalogs for inspiration. |
| **Activity Contents** | **Activity 1 Steps** (Duration:1-2 hours per session, depending on the complexity of designs and available class time) |

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| | **Activity (Introduction to school gardening, research, planning and designing)**<br>**Theoretical part: (15 minutes)**<br>The teacher discusses with students about the importance of school gardens in promoting environmental education, healthy living, and community engagement; show examples of school gardens or community gardens.<br>Students watch short videos about:<br>Video 1 :https://www.youtube.com/watch?v=kjUQkPLVt7M<br>Duration (1min 49sec)<br>Overview: Recycled garden ideas from recycled materials<br>Video 2:https://www.youtube.com/watch?v=fni5898gk-k Duration<br>(8min 06 sec)<br>Overview: This video is about best school garden ideas<br>**Task 1: (30 minutes)**<br>The teacher instructs students to research different types of gardens, plant species, and design ideas they can brainstorm ideas for their school garden designs, considering important factors, they sketch out rough designs and make notes about their design concepts and inspirations.<br>**Task 2: (60-90 minutes)**<br>The teacher gives the students a task to develop design of a school garden and to create content. Students start developing their school garden designs, either by hand or using design software, aiming to ensure practicality and functionality. They write a brief description or rationale for their school garden designs, explaining the goals, features, and benefits of their proposed gardens<br>(encourage them to use clear and persuasive language).<br>**Task 3: (70 minutes)**<br>The teacher gives the students a task to prepare a presentation about their designs.<br>Students practice their presentation skills and prepare to articulate the intentions and merits behind their school garden designs. Then they present their designs to the class, explaining their design choices, objectives, and intended benefits.<br>Students provide constructive criticism and suggestions for improvement on each other's designs, give positive reinforcement and recognition of innovative ideas and thoughtful planning.<br>Students discuss what they learned from the process and reflect on the potential impact of their designs on the school community and the environment.<br>Students clean up their workspaces and organize their materials.<br><br>**Additional Tips:**<br>The teacher should involve other school stakeholders, such as teachers, administrators, parents, and community members, in the design process to ensure diverse perspectives and support for the garden project.<br>The teacher should consider organizing a voting or selection process to choose the final school garden design, involving students, teachers, and community members in the decision-making process. |
| **Assessments** | The teacher evaluates the students' work and achievements through:<br>● Verbal feedback during class; |

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| | • Conversation with/among students;<br>• Monitoring of students during individual and group work;<br>• Observation the individual contribution of each student when working in groups;<br>• Evaluation of students' presentations;<br>• Highlighting the most elegant and ideal solution or Eco-sustainable house;<br>Each student independently evaluates his contribution to the work.<br>The final score is evaluated with a grade. It is possible to involve all students in the class in the assessment. After the presentations, students conduct oral reflection. |
| **Key Competences** | • Cognitive competence<br>• Creativity competence<br>• Communication competence<br>• Social, emotional and healthy living competences<br>• Citizenship competence<br>• Digital competence<br>• Cultural competence |
| **Connections with Eco STEAM** | Eco - Encouraging students to consider the principles of sustainable gardening, such as water conservation, soil health, and native plant selection, in their designs.<br><br>Science - Students will learn which plants thrive in our regions, what kind of soil is needed for these plants to thrive, in what period which plants are best to grow.<br>Technology - Learning how to apply recycling materials to beautify the environment.<br>Engineering - Designing their own model of a school garden using recycling materials.<br>Art - learning to make a sketch of a school garden.<br>Math - Performing various mathematical calculations to find out the price of a possible school garden. |
| **References** | • Academic and scientific literature on garden designs , ecosystems, and conservation.<br>• Online databases and resources for designing a school garden. |
| **Notes** | • The activity should be adaptable to different local ecosystems and weather conditions.<br>• Encouraging students to think about their future role in designing and shaping the space in which they live and work. |

**Assessment Table for Web Quest Reports:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Depth of Research** | _/5 | |
| **Understanding of different plants role** | _/5 | |
| **Accuracy of Information** | _/5 | |
| **Quality of Presentation** | _/5 | |
| **Use of Visuals** | _/5 | |

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**Assessment Table for Group Presentations:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Comprehensiveness of Findings** | _/5 | |
| **Clarity in Presentation of Data** | _/5 | |
| **Understanding of garden design** | _/5 | |
| **Ecological Interpretations and Insights** | _/5 | |
| **Teamwork and Collaboration** | _/5 | |
| **Use of Visual Aids in Presentation** | _/5 | |

| **2.2.4. ACTIVITY PLAN: DEVELOPING TECHNOLOGY-DRIVEN ENVIRONMENTAL SOLUTIONS** | |
|---|---|
| **Introduction part (or activity overview)** | This activity involves students in creating and implementing technology-driven solutions to address specific environmental challenges. The focus is on utilising modern technologies such as sensors, drones, and software applications to develop innovative and practical solutions. The activity aims to develop technical skills, creativity, and a deep understanding of how technology can be applied to environmental issues. |
| **Setting** | Location: Classroom for planning and development, outdoor or lab environment for testing.<br>Educational Context: Collaborative group work. |
| **Materials Needed** | Research materials (books, articles, internet access)<br>Technology tools (sensors, drones, software applications, coding platforms)<br>Prototyping materials (hardware kits, 3D printers, craft supplies)<br>Presentation tools (e.g., PowerPoint, poster boards)<br>Whiteboard and markers |
| **Learning Outcomes** | • Develop skills in utilizing technology to solve environmental problems.<br>• Enhance understanding of the intersection between technology and environmental science.<br>• Improve abilities in project planning, technical implementation, and presentation. |
| **Activity Contents** | **Theoretical Part (Duration: 60 minutes)**: Begin with a detailed introduction to the role of technology in environmental solutions and its potential impacts. |

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- **Introduction to Technology-Driven Environmental Solutions**:
  - Discuss the various ways technology can be used to address environmental challenges. Highlight examples such as remote sensing for monitoring deforestation, drones for wildlife conservation, and software applications for ecological data analysis.
  - Explain the importance of integrating technology with environmental science to develop efficient and scalable solutions.
- **Case Studies of Successful Technology-Driven Solutions**:
  - Discuss how satellite imagery and remote sensing technologies are used to monitor and combat deforestation in real-time. Highlight the economic and environmental benefits of timely data and intervention.
  - Explain how drones are being utilized to monitor wildlife populations, track poachers, and manage protected areas. Discuss the impact of these technologies on conservation efforts and biodiversity.
  - Explore how software applications are used to collect, analyze, and visualize environmental data, aiding in decision-making and policy development.
- **Key Technologies and Tools**:
  - Overview of how sensors and Internet of Things (IoT) devices can be deployed to monitor environmental parameters such as air and water quality, soil moisture, and climate conditions.
  - Explanation of drone technology and its applications in environmental monitoring, mapping, and data collection.
  - Introduction to software tools and coding platforms that can be used to analyze environmental data and develop solutions.
  - Video Resources:

"Technology inEnvironmental Solutions"
https://www.youtube.com/watch?v=6TmSqBz4esU
"Using Drones for Environmental Monitoring"
https://www.youtube.com/watch?v=V-3gzAxpp18

**Discussion Prompts**:

- How can technology enhance our ability to monitor and address environmental issues?
- What are the potential challenges in implementing technology-driven environmental solutions?
- How can we ensure that technological solutions are accessible and scalable?

**Task 1: Technology Research and Selection (Duration: 90 minutes) Objective**: To research and select appropriate technologies for addressing specific environmental challenges.
**Steps**:

1. Divide students into groups, each assigned a different environmental challenge to address using technology.
2. Use provided materials to research various technologies and tools that can be applied to the assigned challenge. Consider factors such as cost, scalability, and ease

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| | of use.<br>3. Select the most suitable technology or combination of technologies for the project. Justify the selection based on the research conducted.<br><br>**Task 2: Project Development and Prototyping (Duration: 120 minutes) Objective**: To develop and prototype technology-driven solutions for the assigned environmental challenges.<br><br>**Steps**:<br><br>1. Create a detailed project plan that outlines the objectives, methodology, and timeline for developing the solution.<br>2. Use the selected technologies to develop prototypes of the solutions. This may involve coding, building hardware, or creating software applications.<br>3. Test the prototypes in a controlled environment or field setting. Collect data on performance and make necessary refinements to improve effectiveness.<br><br>**Task 3: Presentation and Demonstration (Duration: 60 minutes)**<br>**Objective**: To present and demonstrate the developed solutions and receive feedback.<br><br>**Steps**:<br><br>1. Each group creates a presentation that showcases their project, including the problem addressed, technology used, development process, and results. Use visual aids such as slides, videos, or live demonstrations.<br>2. Present the projects to the class, demonstrating how the solutions work and discussing their potential impacts.<br>3. Engage in a Q&A session where peers and instructors provide feedback and ask questions. Discuss potential improvements based on the feedback received. |
| **Assessments** | Appropriateness and effectiveness of the selected technology.<br>Quality and functionality of the prototypes developed.<br>Clarity and persuasiveness of the presentation and demonstration.<br>Ability to defend solutions during the Q&A session.<br>Team collaboration and participation. |
| **Key Competences** | Technical skills in using and developing technology<br>Research and problem-solving skills<br>Project planning and management<br>Effective communication and presentation skills<br>Teamwork and collaboration |
| **Connections with Eco STEAM** | Eco: Using technology to develop practical solutions for environmental challenges.<br><br>Science: Applying scientific principles to design and test solutions.<br>Technology: Utilizing and developing technological tools and applications.<br>Engineering: Creating and refining prototypes to address real-world problems.<br>Arts: Creatively presenting solutions and demonstrating their impact.<br>Math: Analyzing data collected during testing and evaluating the effectiveness of solutions. |

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| **References** | https://www.applus.com/global/en/news/environmental-monitoring-systems:-technology-at-the-service- of-business,-environment,-and-society |
| **Notes** | This activity can be extended into a longer-term project, where students further develop and implement their solutions in real-world settings.<br><br>Encourage students to engage with local environmental organizations or technology experts for real-world insights and support. |

**Evaluation Criteria Table for Developing Technology-Driven Environmental Solutions**

| Evaluation Criteria | Points Available | Comments |
|---|---|---|
| **1. Appropriateness and Effectiveness of Selected Technology** | 20 | Assess the suitability and effectiveness of the chosen technology for addressing the assigned environmental challenge. |
| **2. Quality and Functionality of Prototypes Developed** | 20 | Evaluate the quality, functionality, and innovation demonstrated in the developed prototypes. |
| **3. Clarity and Persuasiveness of Presentation and Demonstration** | 20 | Rate the clarity, persuasiveness, and engagement level of the presentation and demonstration given by each group. |
| **4. Ability to Defend Solutions During Q&A Session** | 20 | Assess the quality and relevance of responses during the Q&A session and the ability to defend the solutions. |
| **5. Team Collaboration and Participation** | 20 | Evaluate the level of teamwork, communication, and participation among group members throughout the activity. |

**Total Points:** 100

## 2.3. SUBTOPIC. ENGINEERING FOR SUSTAINABLE INFRASTRUCTURE

### 2.3.1. ACTIVITY PLAN: DESIGNING SUSTAINABLE INFRASTRUCTURE SOLUTIONS

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| **Introduction part (or activity overview)** | This activity focuses on the integration of engineering principles in the development of sustainable infrastructure. Students will explore how engineering can be applied to enhance sustainability in urban planning, energy systems, and water management. The goal is to develop a conceptual design for a piece of sustainable infrastructure that addresses specific environmental challenges. |
| **Setting** | Location: Classroom equipped with computers, internet access, and resources for model creation (optional physical modeling materials). |

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| | Educational Context: Collaborative group work (2-3 students per group). |
| **Materials Needed** | Computers with internet access for research and design<br>Software for architectural and engineering design (e.g., AutoCAD, SketchUp)<br>Projector and screen for presentations<br>Materials for building physical models (e.g., cardboard, glue, markers) (optional) |
| **Learning Outcomes** | • Understand the role of engineering in developing sustainable infrastructure.<br>• Apply engineering concepts to design a sustainable infrastructure project.<br>• Enhance skills in digital modeling and presentation. |
| **Activity Contents** | **Theoretical Part (Duration: 60 minutes)**: Provide a comprehensive overview of sustainable infrastructure, discussing its importance in modern urban planning, energy conservation, and environmental protection. Highlight engineering solutions like green buildings, renewable energy installations, and eco-friendly water management systems.<br>• **Key Concepts Covered**:<br>  o Principles of sustainable design and construction<br>  o Innovations in green building materials and techniques<br>  o The impact of infrastructure on natural resources and ecosystems<br>• **Video Resources**:<br>  o "Engineering Sustainable Cities" (https://www.youtube.com/watch?v=exampleLink1) – Details how engineers design cities that balance human needs with environmental protection.<br>  o "Innovations in Sustainable Infrastructure" (https://www.youtube.com/watch?v=exampleLink2) – Explores recent engineering advancements in creating more sustainable and resilient infrastructure.<br>**Task 1: Sustainable Infrastructure Case Study (Duration: 90 minutes) Step 1**: Each group selects a real-world example of sustainable infrastructure that integrates innovative engineering solutions. Possible focuses could include energy-efficient building designs, sustainable urban drainage systems, or integrated renewable energy systems.<br>**Step 2**: Conduct in-depth research on the selected project, analyzing:<br>• Engineering principles utilized<br>• Environmental impact and sustainability features<br>• Challenges faced during design and implementation and solutions adopted<br>**Step 3**: Create a detailed presentation of the case study, illustrating the engineering concepts and sustainability outcomes through diagrams, photos, and data.<br>**Task 2: Designing a Sustainable Infrastructure Project (Duration: 120 minutes)**<br>**Step 1**: Identify a local environmental issue that could be addressed through improved infrastructure. Consider factors like energy consumption, water runoff, or urban heat.<br>**Step 2**: Utilize engineering software to design a conceptual model of a sustainable infrastructure solution. The design should include:<br>• A detailed layout that incorporates sustainable materials and technologies<br>• Energy and water conservation features<br>• Integration into the existing urban or natural landscape |

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| | **Step 3**: Each group presents their conceptual design to the class, explaining their design choices, expected sustainability outcomes, and potential community impact. Feedback is solicited from peers and the instructor. |
| **Assessments** | Depth and relevance of case study research<br>Innovation and practicality of the sustainable infrastructure<br>design Technical proficiency in digital modeling and design<br>Clarity and effectiveness of final presentation |
| **Key Competences** | Technical and digital literacy<br>Environmental and sustainability<br>awareness Creative and critical thinking<br>Communication and teamwork |
| **Connections with Eco STEAM** | Engineering: Core focus on applying engineering skills to solve environmental problems.<br><br>Science: Understanding the scientific principles that underpin sustainable infrastructure.<br>Technology: Using advanced software for design and simulation.<br>Arts: Incorporating aesthetic considerations into functional designs.<br>Math: Employing quantitative analysis for design and environmental impact assessment. |
| **References** | https://sustainableinfrastructure.org/ |
| **Notes** | This activity can be extended into a longer-term project where students might interact with local planning or environmental agencies to discuss the feasibility and potential implementation of their designs. |

**Evaluation Table for Engineering for Sustainable Infrastructure Activity**

| Evaluation Criteria | Points Available | Comments |
|---|---|---|
| **1. Depth of Case Study Research** | 20 | Evaluate the thoroughness and depth of the research conducted on the selected sustainable infrastructure case study. |
| **2. Understanding of Engineering Principles** | 20 | Assess the accuracy and application of engineering principles in the analysis of the case study. |
| **3. Innovation in Design** | 20 | Rate the creativity and innovation in the design of the proposed sustainable infrastructure project. |
| **4. Sustainability Features** | 15 | Evaluate how well sustainability features are integrated into the infrastructure design. |
| **5. Technical Proficiency in Modeling** | 10 | Assess the technical skill and accuracy in using engineering software to create digital models. |

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| **6. Clarity and Organization of Presentation** | 10 | Judge the effectiveness of the presentation in terms of clarity, organization, and the use of visual aids. |
| **7. Team Collaboration and Interaction** | 5 | Rate the level of effective collaboration and contribution from all team members throughout the project. |

**Total Points:** 100

| **2.3.2. ACTIVITY PLAN: FROM PAPER TO BLINDS** | |
|---|---|
| **Introduction part (or activity overview)** | This activity is aimed to use paper in a rational way to create blinds or curtains of mathematical shapes strung on string with proposing practical solutions. In this way, paper pollution in the environment will be reduced and it will play a significant role in arranging one's staying or living place and it will also develop students' awareness in respecting and meeting some important sustainability goals. |
| **Setting** | Classroom |
| **Materials Needed** | Computer (phone or tablet can be used to watch the videos, to do some calculations), projector (to present works or videos to students), paper, pencils, scissors, ropes or stitches, egg's white, sugar, salt, water, flour, pan for heating, bottle to collect the homemade glue. |
| **Activity Contents** | **Activity: From paper to blinds**<br>**Theoretical Part (Duration: 30 minutes)**: Exchange opinions about the large quantity of paper that is not used for practical purposes. How can paper and cardboard be used to explain agrid of some geometric figures and solids? Clarify the net of cubes, prisms, pyramids, cylinders and cones. Analyze how these nets are made of some materials. Present how paper can be used for unique design for the blinds or wall decorations. Discuss the techniques used for the creation of blinds.<br><br>**Task 1 (Duration: 20 minutes)** Students do research about production of glue with natural ingredients mentioned in the section Materials Needed or by using tree resin, if students can collect in the nature. In this first phase, the students should also investigate how they can reuse paper, taking into account which type of paper can be used for the appropriate purpose, while not disrupting the further processes for recycling that product. (Don't use lots of plastic or paint)<br>Short videos about the process of making glue:<br>How To Make Glue With Egg White? Glue With Egg White Experiment \| Easy Science Experiments For Kids - YouTube (Duration: 1:35)<br>How to make homemade glue \| homemade favicol \|super Strong white glue at home - YouTube (Duration: from 0:47 till 4:30)<br>Overview: Explanation of the process of preparing glue for our paper blinds.<br><br>**Task 2 (Duration: 60 minutes)**<br>Schoolchildren, working in small groups or even pairs, make the paper blinds.<br>Students decide about the types of solids made of paper for the wall decorations, the color |

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| | they will use for painting the blinds after they are created. Also, students decide on the price of this original homemade product.<br><br>Videos for creation of the blinds:<br>https://www.youtube.com/watch?v=GeE-SIP0yPE (Duration: 9:35)<br>https://www.youtube.com/watch?v=2g9vCfrn4MA (Duration: 8:29)<br>Overview: In these videos you will find out about the techniques for creating the blinds from paper. Students can get the idea and make it more creative.<br><br>https://www.youtube.com/watch?v=_95S6j3WUOo (Duration: 10:29)<br>https://www.youtube.com/watch?v=u_gn4S-0mhA (Duration: 7:54)<br>Overview: These videos demonstrate the ways of creating wall or window decorations from paper. |
| **Assessments** | The teacher evaluates the students' work and achievements through:<br>● Verbal feedback during the class;<br>● Conversation with/among the students;<br>● Monitoring of students during individual and group work.<br>● Observation the individual contribution of each student when working in groups<br>● Evaluation of students' work and creation of the blinds<br>The final score is evaluated with a grade. It is possible to involve all students in the class in the assessment. Each student self-assesses his contribution to the work. |
| **Key Competences** | ● Cognitive competence<br>● Creativity competence<br>● Communication competence<br>● Social, emotional and healthy living competences<br>● Citizenship competence<br>● Digital competence<br>● Cultural competence |
| **Connections with Eco STEAM** | **Eco -** Ecological awareness about the need to reuse paper before recycling it.<br><br>Science - Knowledge of chemistry for making glue.<br>Technology - The use of applications for creating the design of blinds.<br>Engineering - Through creativity the students have to create blind mechanisms.<br>Art - From a bird's eye view or oblique perspective, the planted area should be interesting and beautiful for the human eye.<br>Math - Mathematical models of solid and 2-D figures. |
| **References** | |
| **Notes** | Encouraging students to think about their future role in designing and shaping the space in which they live and work |

**Assessment Table for Web Quest Reports:**

| Assessment Criteria | Points | Comments |
|---|---|---|

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| **Creativity for the design** | _/5 | |
| **Strategy for the creation of the blinds** | _/5 | |
| **Use of types of paper** | _/5 | |
| **Understanding Math models** | _/5 | |

| **2.3.3. ACTIVITY PLAN: GREEN TRANSPORTATION SOLUTIONS** | |
|---|---|
| **Introduction part (or activity overview)** | This activity focuses on exploring and designing green transportation solutions as a critical component of sustainable infrastructure. Students will delve into the environmental impacts of current transportation systems and apply engineering principles to propose innovative, sustainable transportation alternatives. |
| **Setting** | Location: Classroom equipped with computers, internet access, and tools for creating digital and physical models.<br><br>Educational Context: Collaborative group work (2-3 students per group) |
| **Materials Needed** | Computers with internet access for research and design simulations<br>Software for transportation modeling and design (e.g., Autodesk, Civil 3D) Projector and screen for presentations<br>Materials for building small-scale models (optional) |
| **Learning Outcomes** | • Understand the environmental challenges associated with traditional transportation systems.<br>• Apply engineering concepts to design sustainable transportation solutions.<br>• Develop skills in digital modeling and persuasive presentation. |
| **Activity Contents** | **Theoretical Part (Duration: 60 minutes)**: Provide a comprehensive overview of the challenges posed by conventional transportation systems, including their contributions to air pollution, greenhouse gas emissions, and urban sprawl. Introduce the concepts of sustainable transportation, such as electric vehicles, public transit systems, cycling infrastructure, and pedestrian-friendly urban design.<br>• **Key Concepts Covered**:<br>o Environmental impact of different modes of transportation.<br>o Principles of sustainable transportation design.<br>o Technological innovations in transportation, like autonomous vehicles and smart infrastructure.<br>• **Video Resources**:<br>o "The Future of Transportation" (https://www.youtube.com/watch?v=exampleLink1) – Discusses emerging trends and technologies in sustainable transportation.<br>o "Engineering Smarter Ways to Travel" (https://www.youtube.com/watch?v=exampleLink2) – Showcases |

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| | engineering solutions that have successfully mitigated transportation-related environmental impacts.<br>**Task 1: Analyzing Current Transportation Systems (Duration: 90 minutes)**<br>**Step 1**: Each group selects a city and researches its main transportation challenges, focusing on environmental impacts.<br>**Step 2**: Conduct an analysis that includes:<br>● Current transportation modal share and its environmental repercussions.<br>● The city's existing policies and infrastructure concerning transportation.<br>**Step 3**: Present a critical review of the city's transportation system, using data visualization tools to highlight key issues and areas for improvement.<br>**Task 2: Designing a Sustainable Transportation Model (Duration: 120 minutes)**<br>**Step 1**: Based on their analysis in Task 1, students design a comprehensive sustainable transportation solution for the selected city. Consider integration of multiple transport modes, use of renewable energy sources, and enhancement of urban connectivity.<br>**Step 2**: Develop a detailed project plan that includes:<br>● Proposed changes and additions to the current infrastructure.<br>● Expected environmental and social benefits.<br>● Implementation phases and potential challenges.<br>**Step 3**: Utilize digital modeling tools to create a visual representation of the proposed transportation model.<br>**Step 4**: Each group presents their design to the class, explaining the rationale behind their choices and the expected impact of their model. |
| **Assessments** | Depth of analysis on current transportation issues.<br>Innovation and sustainability of the proposed transportation model.<br>Technical proficiency in using digital modeling tools.<br>Clarity and persuasiveness of the final presentation. |
| **Key Competences** | Analytical and problem-solving skills<br>Technical and digital literacy<br>Creative and innovative thinking<br>Communication and teamwork |
| **Connections with Eco STEAM** | Engineering: Core focus on applying engineering solutions to environmental challenges in transportation.<br>Science: Understanding the environmental science behind transportation emissions and impacts.<br>Technology: Using advanced technology for simulation and modeling. Arts:<br>Creatively presenting transportation models and data.<br>Math: Utilizing mathematical models to predict outcomes and impacts. |
| **References** | Institute for Transportation and Development Policy https://itdp.org/ |
| **Notes** | This activity can extend into a project-based learning experience where students can engage with local city planners or transportation experts to discuss the feasibility of their proposals. |

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**Evaluation Table for Green Transportation Solutions Activity**

| Evaluation Criteria | Points Available | Comments |
|---|---|---|
| **1. Depth and Accuracy of Transportation Analysis** | 20 | Evaluate the thoroughness and accuracy of the analysis conducted on the existing transportation systems and their environmental impacts. |
| **2. Innovation in Sustainable Transportation Design** | 20 | Rate the creativity and innovation in the design of the proposed sustainable transportation solutions. |
| **3. Application of Engineering Principles** | 20 | Assess how effectively engineering principles are applied in the proposed transportation solutions. |
| **4. Technical Proficiency in Digital Modeling** | 15 | Evaluate the skill and accuracy in using digital tools to model the transportation solutions. |
| **5. Sustainability Features Integration** | 10 | Judge how well sustainability features are integrated into the transportation design (e.g., energy efficiency, multimodal integration). |
| **6. Clarity and Organization of Presentation** | 10 | Assess the effectiveness of the presentation in terms of clarity, organization, and the use of visual aids. |
| **7. Team Collaboration and Interaction** | 5 | Rate the level of effective collaboration and contribution from all team members throughout the project. |

**Total Points:** 100

| **2.3.4. ACTIVITY PLAN: WATER RESOURCE MANAGEMENT SYSTEMS** | |
|---|---|
| **Introduction part (or activity overview)** | This activity explores the engineering principles behind designing sustainable water resource management systems. Students will delve into hydrological cycles, water treatment technologies, and sustainable practices to manage water resources efficiently, considering both urban and rural settings. |
| **Setting** | Location: Classroom equipped with computers, internet access, and necessary tools for creating simulations or physical models.<br><br>Educational Context: Collaborative group work (2-3 students per group) |
| **Materials Needed** | Computers with internet access for research and simulations<br>Software for environmental modeling (e.g., HEC-HMS, Aqua3D)<br>Projector and screen for presentations<br>Materials for building physical models of water management systems (optional) |
| **Learning Outcomes** | • Understand hydrological processes and the impact of human activities on |

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| | water cycles.<br>● Apply engineering principles to design effective and sustainable water management systems.<br>● Develop skills in environmental simulation, data analysis, and project presentation. |
| **Activity Contents** | **Theoretical Part (Duration: 90 minutes)**: This segment provides an in-depth exploration of the science and engineering principles that underpin the sustainable management of water resources, a critical issue given the global challenges of water scarcity, pollution, and the impacts of climate change. The session will delve into the hydrological cycle, the engineering solutions currently in practice, and the emerging technologies that promise greater sustainability.<br>● **Understanding the Hydrological Cycle**: Begin with a detailed review of the hydrological cycle, explaining processes such as evaporation, condensation, precipitation, infiltration, and runoff. Highlight how these natural processes are impacted by human activities like urbanization, agriculture, and industrialization.<br>● **Water Scarcity and Pollution Challenges**: Discuss global water issues, focusing on scarcity and pollution. Examine case studies from around the world where water scarcity has led to serious social and economic repercussions. Explore the sources of water pollution, including agricultural runoff, industrial discharges, and improper waste disposal, and their effects on ecosystems and human health.<br>● **Sustainable Water Management Principles**: Introduce students to the principles of sustainable water management which include reducing demand, increasing supply through non-conventional sources, and improving water quality via natural and engineered systems. Discuss the role of water conservation strategies such as rainwater harvesting, water-efficient fixtures, and xeriscaping in urban planning.<br>● **Innovations in Water Engineering**: Cover advanced water treatment technologies like reverse osmosis, ultraviolet disinfection, and membrane bioreactors. Discuss the integration of 'smart' water management systems using IoT technology that allows for real-time monitoring and control of water use. Examine how renewable energy sources are being used to power water treatment plants, reducing the carbon footprint associated with water management.<br>● **Adaptation to Climate Change**: Analyze how engineering solutions can help adapt to the impacts of climate change on water resources. This includes the construction of resilient water infrastructure capable of withstanding extreme weather events and sea-level rise, and the restoration of natural ecosystems such as wetlands to enhance water regulation and purification.<br>● **Video Resources**:<br>o **"Comprehensive Guide to the Hydrological Cycle"** (https://www.youtube.com/watch?v=exampleLink1) – Provides an animated explanation of the hydrological cycle, emphasizing its relevance to environmental management.<br>o **"Engineering Innovations in Water Sustainability"** (https://www.youtube.com/watch?v=exampleLink2) – Showcases cutting-edge engineering technologies that are making water systems more sustainable and resilient.<br>**Task 1: Water System Analysis (Duration: 90 minutes) Step 1**: Each group selects either an urban or rural area and researches its water management challenges and current systems in |

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| | place.<br>**Step 2**: Perform a detailed analysis that includes:<br>● Evaluation of existing water supply and sanitation infrastructure.<br>● Identification of key issues such as water loss, contamination, or inadequate supply.<br>**Step 3**: Create a comprehensive presentation that outlines the findings, supported by data visualization tools such as maps, flow diagrams, and graphs.<br>**Task 2: Designing a Sustainable Water Management Model (Duration: 120 minutes) Step 1**: Based on the analysis in Task 1, students design a conceptual model for a sustainable water resource management system tailored to the chosen area.<br>**Step 2**: Develop a detailed project plan that includes:<br>● Proposed engineering solutions for water conservation, treatment, and distribution.<br>● Integration of innovative technologies like IoT for smart water management or renewable energy-powered desalination plants.<br>● Environmental and socio-economic impact assessments.<br>**Step 3**: Utilize digital modeling tools or physical models to demonstrate the proposed system. **Step 4**: Each group presents their model to the class, highlighting design rationale, expected benefits, and potential challenges. |
| **Assessments** | Depth and accuracy of hydrological and infrastructure analysis.<br>Innovation and sustainability of the water management system design.<br>Effectiveness of digital or physical modeling.<br>Clarity and persuasiveness of the presentation. |
| **Key Competences** | Analytical and technical skills<br>Environmental awareness<br>Project management and planning<br>Communication and teamwork |
| **Connections with Eco STEAM** | Eco Science: Understanding the scientific principles that govern water cycles and treatment processes.<br>Engineering: Applying engineering concepts to solve real-world environmental challenges in water management.<br>Technology: Using advanced software and technologies for system design and simulation.<br>Arts: Creatively presenting project plans and models.<br>Math: Employing quantitative methods to analyze water systems and predict the outcomes of proposed solutions. |
| **References** | https://www.gwp.org/ Global Water Partnership |
| **Notes** | Consider extending this activity into a project-based learning module, where students could potentially engage with local water authorities or environmental agencies to discuss the feasibility and implementation of their designs. |
| **Evaluation Table for Water Resource Management Systems Activity** | |

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| Evaluation Criteria | Points Available | Comments |
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| **1. Depth and Accuracy of Hydrological Analysis** | 20 | Evaluate the thoroughness and accuracy of the analysis conducted on the hydrological cycle and water management issues. |
| **2. Understanding of Sustainable Water Management Principles** | 20 | Assess the accuracy and application of sustainable water management principles in the proposed solutions. |
| **3. Innovation in Water Management Solutions** | 20 | Rate the creativity and innovation in the design of the proposed water resource management systems. |
| **4. Technical Proficiency in Digital Modeling** | 10 | Evaluate the skill and accuracy in using digital tools to model the water management solutions. |
| **5. Sustainability Features Integration** | 10 | Judge how well sustainability features are integrated into the design (e.g., use of renewable energy, water recycling technologies). |
| **6. Clarity and Organization of Presentation** | 10 | Assess the effectiveness of the presentation in terms of clarity, organization, and the use of visual aids. |
| **7. Team Collaboration and Interaction** | 10 | Rate the level of effective collaboration and contribution from all team members throughout the project. |

**Total Points:** 100

| **2.3.5. ACTIVITY PLAN: GEOMETRIC DOME MODEL** | |
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| **Introduction part (or activity overview)** | This activity aims to help explore geometric principles and sustainable architecture by creating geodesic dome models. Practically constructing these domes delves into the structural intricacies of geodesic domes, learning about their energy-efficient design and ecological implications. |
| **Setting** | Classroom |
| **Materials Needed** | Sheets of paper (draft paper can be used), adhesive tape, scissors, pencils, ruler, adhesive glue sticks. |
| **Learning Outcomes** | • Deepen understanding of tension and compression forces and how they contribute to the integrity of engineering structures.<br>• Improve communication and collaboration skills in planning, designing, and constructing their models.<br>• Gain insight into sustainable architecture by exploring energy-saving features of geodesic dome designs.<br>• Acquire practical experience similar to that encountered by engineers and architects when creating structures.<br>• Apply mathematical principles, geometric concepts such as triangles, |

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| | polygons, and spatial relationships in a practical context. |
| **Activity Contents** | **Activity1: Geodesic Dome Model**<br><br>**Theoretical Part (Duration: 30 minutes):** This activity begins with an introduction to geodesic domes as unique and efficient structural examples that have great appeal due to their exceptional design and functionality. It is important to emphasize that geodesic domes stand out for their geometric complexity, providing elegance and style to architectural landscapes, while also being energy-efficient and environmentally beneficial.<br><br>**Videos:**<br><br>https://www.youtube.com/watch?v=TqxarO-5igc<br><br>Overview: Geodesic dome structural analysis<br><br>basics Duration: Approx.16 minutes<br><br>https://www.youtube.com/watch?v=jlD5yr45TiU&list=RDCMUCL--oBARR8PwZtH7drz5Sjw&index=42 Overview: Construction of a Geodesic Dome<br><br>Duration: Approx.2.33 minutes<br><br>**Task (Duration: 1.5 hours):** In this practical activity, students, working in groups, will construct a geodesic dome model using paper straws. This task is designed to understand the basic principles underlying geodesic structures.<br><br>Step 1: Group formation, distribution of materials. (5 minutes)<br><br>Step 2: Making paper straw segments and assembling the geodesic dome model. Description of the workflow (Attachment 1). (70 minutes)<br><br>Step 3: Presentation of the model and a brief discussion to review the main conclusions and lessons learned. (15 minutes) |
| **Assessments** | The task is evaluated with grades (Annex 2). |
| **Key Competences** | Cognitive competence<br>Creativity competence<br>Communication competence |
| **Connections with Eco STEAM** | Eco - A construction method aimed at reducing environmental impact and promoting sustainability in architectural design.<br><br>Science - Physics, geometry, and materials science.<br>Technology - The intersection of technology and architecture, demonstrating construction efficiency.<br>Engineering - Application of engineering principles in creating robust and efficient architectural structures.<br>Art - Visually striking architectural artwork. |

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| | Math - Mathematical modeling |
| **References** | https://www.youtube.com/watch?v=pGaJju6A6Qo<br>https://www.youtube.com/watch?v=Ym1388CcwuQ<br>https://www.youtube.com/watch?v=Gl71iOkeIDo&t=28s |
| **Notes** | |

## ANNEX 1
## DESCRIPTION OF THE WORKFLOW

| | Workflow information | Example |
|---|---|---|
| **Paper Straw Making.** | You need to make 65 paper straws: 35 longer ones and 30 shorter ones. The shorter straws are 88.3% of the length of the longer ones. You will cut the paper into strips of the chosen length and 5 cm width. Then, you will wrap these strips around pencils and glue them. | Example: A dome with a diameter of 38 cm is made from 35 straws, each 12 cm long, and 30 straws, each 10.6 cm long. The longer straws are made from white paper, while the shorter ones are made from blue.   |
| **Gluing the dome** | Glue together the decagon using the longer straws (10 pieces). Use translucent adhesive tape for gluing. Leave a gap when gluing the straws so that you can bend them. | Example :   |

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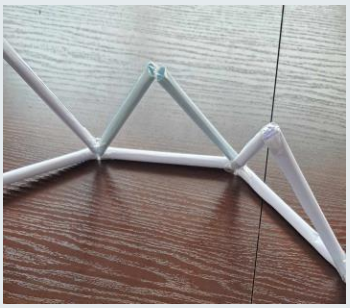
| At each junction, connect one shorter and one longer straw. With each side of the decagon, alternate between equilateral and isosceles triangles. Use up 10 longer and 10 shorter straws. | Example:   |
| Connect the vertices of triangles with shorter straws (10 pieces). | Example:  |
| Connect 5 shorter straws to form pentagons. Connect 10 longer straws to form hexagons. Complete the circle with 5 longer straws. | Example:  |
| Connect the last 5 shorter straws into one point, and attach the other ends to the dome. | Example:  |

**Annex 2 Assessment Table:**

| Evaluation criteria: | Points | Comments |
|---|---|---|
| **Model accuracy** | _/5 | |

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| **Model aesthetics** | _/5 | |
| **Collaboration** | _/5 | |
| **Presentation** | _/5 | |

## 2.4. SUBTOPIC. MATHEMATICS IN ENVIRONMENTAL MODELING AND ANALYSIS

| **2.4.1. ACTIVITY PLAN: 3-D WASTE MODELS** | |
|---|---|
| **Introduction part (or activity overview)** | Math and art classes can be combined to produce so-called 3D waste models. Through this activity the students engage in environmental education and math skills in designing 3D mathematical models for waste collection, create a bond with the environment and to appreciate the generosity of nature, develop positive attitude towards nature, and prevent pollution. Also, students are empowered to apply the acquired knowledge in a collaborative project with a concrete result and a positive outcome towards nature. |
| **Setting** | Classroom and outdoor work (depending on the weather conditions) |
| **Materials Needed** | Computer (phone or tablet can be used to collect information, to do some calculations), projector (to present works), materials like cardboard (thick, sturdy), strong adhesive or packing tape, specific number of uniform plastic bottles and bottle caps, wine corks, plastic straws, scissors or utility knife, drill (if using zip ties), wood sticks, glue, ruler or measuring tape, paper or paint in different colors for garbage selection, but as well some materials that could be reused in the process of making these models. |
| **Learning Outcomes** | • Gain a deeper understanding about the need for trash cans.<br>• Develop critical thinking for the application of mathematics in the making of these wastebasket models.<br>• Learn to search, investigate and calculate the materials and area of materials (cardboard, plastic bottles and caps,) for the 3D models.<br>• Acquire interdisciplinary knowledge and obtain informal knowledge about solid geometry.<br>• Increase ecological awareness. |
| **Activity Contents** | **Activity: 3-D Waste models**<br>**Theoretical Part (Duration: 20 minutes)**: Discuss the importance of bins for collecting garbage and decrease environmental damage. Analyze the materials necessary for bins' modelling. Present how certain resources can be used for unique designs. Confer about the math behind the creation of the bins using AutoCAD and GeoGebra applications.<br>Explain how important the shape of trash bins is concerning bacteria growth, since the edges are more susceptible for bacteria. Students research this information and discover facts about the significance of sorting garbage properly.<br>Giving examples of 3-D waste models through images:<br>**Task 1 (Duration: 10 minutes)** Students research production of oxygen and connections with biology and the process of photosynthesis. Students research |

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scientific facts for the process and come up with interesting facts aiming to surprise the other listeners of this activity. Students do calculations about the usage of CO2 and production of oxygen.

Short video about the science of trash:

https://www.youtube.com/watch?v=x4x8HsAhp8U (Duration: 8:39)

Overview: Explanation of how humanity has dealt with it (or not) over the ages, and both risks and the potential this process holds for the future.

**Task 2 (Duration: 90-120 minutes)** Collect information about the techniques and types of materials used for the bin's creation. Students start developing the bin's design, either by hand or using design software, inclined to ensure stable construction of bins.

Schoolchildren, working in larger groups, make bins for the school, could even consider the opportunity for business ideas. (If the bins are made for the school's yard the students will have to take in account all the weather condition through the year):

- Each group must examine one type of materials used for the pots (e.g. paper, cardboard, plastic, cans, straws, corks, etc.).
- Each student in the group has an assigned role (e.g., group leader and supervisor, data collector, data analyst, environmental impact predictor, speaker and presenter, everyone who works on the product etc.).

For the choice of materials for the bins:

https://www.pinterest.com/wastewise/eco-friendly-recycling-bins/

Videos about the different ways of producing the waste models:

https://www.youtube.com/watch?app=desktop&v=WC9i9bfJkC0 (Duration: 5:17)

https://www.youtube.com/watch?v=bR4S8U8xKcQ (Duration: 1:57)

https://www.youtube.com/watch?v=dyl8rliDpNg (Duration: 10:03)

https://www.youtube.com/watch?v=2dj-Tj829Kw (Duration: 3:47)

https://www.youtube.com/watch?v=FpU9oOwCj-8 (Duration: 7:00)

https://www.youtube.com/watch?v=dOVxbX6LCz4 (Duration: 7:30)

**Task 3 (Duration: 30 minutes)** Presentation of methods used for the creation of the bins.

- Students practice their presentation skills and prepare to articulate the intentions and merits behind their bin's design. Then they present their designs to the class, explaining their design choices, math objectives, and intended benefits from the idea.
- Students provide constructive criticism and suggestions for improvement on each other's designs.
- Students discuss what they learned from the process and reflect on the potential impact of their design of bins.
- Students clean up their workspaces, organize their materials, and discuss what to do with the waste and excess materials.

**Additional Tips**

Questions that will help students with their research:

1. Make a decision on the shape of the bin (cylinder, cone, prism, pyramid, sphere, or combined).

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|---|---|
| | 2. Analyze the area for constructing the model.<br>3. Look over the ecological impact on the environment by making these models.<br>4. Evaluate the best-generated spots for placing the bins and cans.<br>5. Prepare presentations (poster) and present them to classmates (or between classes). |
| **Assessments** | The teacher evaluates the students' work and achievements through:<br>● Verbal feedback during class;<br>● Conversation with/among students;<br>● Monitoring of students during individual and group work;<br>● Observation of the individual contribution of each student when working in groups;<br>● Evaluation of students' presentations;<br>● Highlighting the most efficient 3D waste models;<br><br>The final score is evaluated with a grade. It is possible to involve all students in the class in the assessment. Each student self-assesses his contribution to the work. After the presentations, students can make a competition about the best-made wastebasket design with online voting<br>and questionnaires. |
| **Key Competences** | ● Cognitive competence<br>● Creativity competence<br>● Communication competence<br>● Social, emotional and healthy living competencies<br>● Citizenship competence<br>● Digital competence<br>● Cultural competence |
| **Connections with Eco STEAM** | **Eco -** Increasing environmental awareness for environmental preservation, pollution prevention and waste selection<br><br>Science - Combining knowledge from biology, physics and chemistry to create a quality model.<br>Technology - The use of special mobile applications or computer software to create the bins/cans.<br>Engineering: The students have to create the best-constructed trash bins through creativity.<br>Art: The students use artistic techniques to decorate the trash cans and give them a beautiful design that leaves a special impression on the environment where they are placed.<br>Math - Calculate the area for constructing the bins, the volume of the garbage inside the trash cans and choose the best shape for this ecological purpose, perform mathematical calculations to find out about the bacteria growth (if possible and depending on the used material for the 3-D waste models). |
| **References** | ● Academic and scientific literature on math models and shapes.<br>● Literature for the biological studies about types of materials and shapes that prevent an increase in the number of bacteria in and out of the bins. |
| **Notes** | ● The activity should be adaptable everywhere.<br>● Encouraging students to think about their future role in making zero waste in nature. |

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**Assessment Table for Web Quest Reports:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Depth of Research** | _/5 | |
| **Understanding of different solid 3D shapes** | _/5 | |
| **Creativity for choice of materials** | _/5 | |
| **Quality of Presentation** | _/5 | |
| **Use of types of materials** | _/5 | |

**Assessment Table for Group Presentations:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Comprehensiveness of Findings** | _/5 | |
| **Clarity in Presentation of Data (Calculations)** | _/5 | |
| **Understanding of bins design** | _/5 | |
| **Ecological Interpretations and Insights** | _/5 | |
| **Teamwork and Collaboration** | _/5 | |

**2.4.2. ACTIVITY PLAN: ELECTRICITY AUDIT AT HOME**

| | |
|---|---|
| **Introduction part (or activity overview)** | This activity is aimed at analyzing household energy consumption, identifying inefficiencies, and proposing practical solutions. By thoroughly examining appliances, lighting, and habits, conclusions will be drawn regarding energy usage and potential savings methods. This enables households to make informed decisions, reduce their environmental impact, and contribute to broader sustainability goals. |
| **Setting** | Classroom<br><br>Students living environment |
| **Materials Needed** | Notebooks and pens<br><br>Digital devices (tablets/laptops) |

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|---|---|
| **Learning Outcomes** | • Deepen the comprehensive understanding of how electricity is consumed in households.<br>• Improve data collection and analysis skills.<br>• Evaluating energy usage methods and devising strategies to optimize efficiency and reduce overall electricity consumption will enhance critical thinking and problem-solving skills.<br>• Foster a sense of responsibility for sustainability by conserving resources. |
| **Activity Contents** | **Activity1: Electricity Audit at Home**<br><br>**Theoretical Part (Duration: 45 minutes):** Discuss the power of household electrical appliances and the amount of energy consumed. Analyze which appliances are high-power and which are low-power. Help understand energy consumption efficiency classes. Discuss various energy-saving methods.<br>**Videos:**<br><br>https://www.youtube.com/watch?v=ziyslQq_eeA<br>Overview: This video shows how much electricity household appliances consume and analyzes appliance power indicators.<br>Duration: Approx. 8.5 minutes<br><br>https://www.youtube.com/watch?v=JX4FC6tJLlI<br>Overview: This video discusses the new revised EU energy label that has been in effect since March 1, 2021. It explains how to easily choose the most energy-efficient product within your budget.<br>Duration: Approx.1.6 minutes<br><br>https://www.youtube.com/watch?v=EB9I2Wp7stg<br><br>Overview: In this video we will tell you 20 ways you can save electricity and money at home. Frugal living is the essence and requires we go over all expenses that can be avoided.<br>Duration: Approx.12 minutes<br><br>**Task 1 (Duration: 60 minutes):** Students conduct an electricity audit in their homes according to the provided (or self-created) plan. Annex No. 1 must be explained thoroughly.<br><br>**Task 2 (Duration: 30-45 minutes):** Discussion of the tasks. Each student presents one statement from the conclusions. Those who wish can present their work. |
| **Assessments** | Students' work is individually assessed by grade according to the assessment table (Annex No. 2). |
| **Key Competences** | Communication competence<br>Digital competence<br>Cultural competence<br>Social, emotional and healthy living competences<br>Creativity competence<br>Citizenship competence |

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| | |
|---|---|
| **Connections with Eco STEAM** | Eco - Environmental sustainability is emphasized, promoting energy efficiency.<br><br>Science – Knowledge of physics and economics.<br>Technology - Examines energy-saving technologies and devices to optimize electricity consumption.<br>Engineering - Develops energy efficiency solutions by identifying areas of energy waste.<br>Art - Creativity and innovation in exploring aesthetic and functional designs for energy-saving lighting, devices, and home systems.<br>Math - Utilizes mathematical models, calculations, and data analysis. |
| **References** | https://www.youtube.com/watch?v=Dk5wfKPx0q4<br>https://www.youtube.com/watch?v=qTaaErZJJHI<br>https://www.youtube.com/watch?v=x5iG9x6RjGA<br>https://www.whirlpool.lt/Innovation-Design/Naujos-energijos-vartojimo-efektyvumo-klases |
| **Notes** | |

**Annex No. 1**
**Electricity audit at home (Example)**

| **Electricity energy audit goal (objectives):** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Amount of electricity consumed per month (kWh):** | | | | | | | | |
| **Number of rooms:** | | | | | | | | |
| **Number of family members:** | | | | | | | | |
| **Appliance** | **Power rating (in watts)** | **Age (years), condition** | **Efficiency class** | **Bulb type, (for bulb only)** | **Power consumption in standby mode (in watts)** | **Monthly usage schedule, consumed energy** | **Energy-saving features** | **Notes on reducing electricity consumption** |
| **Example:**<br><br>**Kettle** | 1800 W | 5 years,<br><br>Contains lime | B | - | - | About 15 hours<br><br>27 kWh | - | Low efficiency class, contains lime, which absorbs energy |
| **Example: 3**<br><br>**bulbs** | 40x3=120W | 1-2 metai | G | Incandescent | - | About 90 hours<br><br>10,8 kWh | - | By replacing them with LED bulbs, we would consume about 1.2 kWh. |

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| Conclusions: |
|---|

**Annex No.2 Assessment Table**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Formulating the goal(s)** | _/1 | |
| **Filling out the table** | _/7 | |
| **Conclusions** | _/2 | |
| **Overall assessment** | _/10 | |

| **2.4.3. ACTIVITY PLAN: ANALYZING ENVIRONMENTAL IMPACT USING MATHEMATICAL MODELS** | |
|---|---|
| **Introduction part (or activity overview)** | This activity aims to teach students how to use mathematical models to analyze and predict the environmental impact of human activities. Students will gather data, apply mathematical concepts, and create models to understand and mitigate environmental damage. |
| **Setting** | Location: Classroom and computer lab for research and analysis.<br>Educational Context: Collaborative group work (4-5 students per group). |
| **Materials Needed** | Computers with internet access and relevant software (e.g., spreadsheets, mathematical modeling tools)<br>Access to online data sources for environmental statistics<br>Projector for presentations<br>Graph paper, calculators, and other mathematical tools |
| **Learning Outcomes** | ● Understand the role of mathematics in environmental impact analysis.<br>● Develop skills in data collection, mathematical modeling, and impact assessment.<br>● Enhance abilities in research, project development, and presentation. |
| **Activity Contents** | **Theoretical Part (Duration: 60 minutes)**: Begin with an introduction to the importance of mathematics in analyzing the environmental impact of human activities. Highlight various mathematical methods and tools used in impact assessment.<br>● **Introduction to Environmental Impact Assessment (EIA)**:<br>o Explain what Environmental Impact Assessment (EIA) is and why it is crucial for sustainable development. Discuss how EIAs help in understanding the potential environmental consequences of proposed projects before they are carried out.<br>o Break down the key components of an EIA, including screening, scoping, impact analysis, mitigation measures, public participation, and decision- |

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making.

- **Mathematical Methods in Environmental Analysis**:
  - Discuss how statistical methods such as regression analysis, correlation analysis, and hypothesis testing are used to analyze environmental data and identify trends and patterns.
  - Explain the principles of cost-benefit analysis and how it is used to weigh the environmental costs and benefits of a project. Provide examples of how mathematical calculations are used to determine the net benefits.
  - Introduce computational models such as air quality models, water quality models, and climate models. Discuss the mathematical foundations of these models and their applications in predicting environmental impacts.
  - Explain the use of differential equations in modeling dynamic environmental systems. Provide examples of how these equations are used to simulate the behavior of ecosystems over time.
- **Case Studies**:
  - **Case Study 1: Air Quality Modeling**: Present a case study on how mathematical models are used to predict air pollution levels in urban areas. Discuss the data inputs, modeling techniques, and the outcomes of the study.
  - **Case Study 2: Water Quality Analysis**: Share a case study on the application of statistical methods to assess water quality in a river. Highlight the data collection process, analysis methods, and the environmental implications of the findings.

**Discussion Prompts**:

- How can mathematical models help in predicting the long-term impacts of human activities on the environment?
- What are the limitations of using mathematical models in environmental impact assessments?
- How can public participation be integrated into the process of environmental impact assessment?

**Task 1: Data Collection and Analysis (Duration: 45 minutes) Objective**: To collect and analyze data on the environmental impact of a specific human activity.

- **Step 1**: Form groups and assign each group a specific human activity to study (e.g., deforestation, industrial pollution, urbanization).
- **Step 2**: Use online data sources to collect historical data on the environmental impact of the assigned activity.
- **Step 3**: Input the data into a spreadsheet or mathematical software to analyze trends, patterns, and anomalies.
- **Step 4**: Use statistical methods to interpret the data and draw conclusions.

**Task 2: Mathematical Modeling (Duration: 90 minutes) Objective**: To create a mathematical model that predicts the future environmental impact of the assigned human activity.

- **Step 1**: Based on the data analysis, develop a mathematical model using relevant methods (e.g., regression analysis, differential equations).
- **Step 2**: Use the model to predict future impacts of human activity under different

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| | scenarios (e.g., increased activity, implementation of mitigation measures).<br>• **Step 3**: Validate the model by comparing its predictions with actual data and adjust as necessary.<br>• **Step 4**: Prepare a presentation summarizing the data analysis, model development, predictions, and potential solutions based on the model.<br>**Task 3: Presentation and Feedback (Duration: 45 minutes) Objective**: To present the mathematical model and analysis to the class and receive feedback.<br>• **Step 1**: Each group presents their data analysis, mathematical model, and predictions to the class.<br>• **Step 2**: Conduct a Q&A session where other students and the instructor can provide feedback and ask challenging questions.<br>• **Step 3**: Groups reflect on the feedback received and discuss potential improvements. |
| **Assessments** | Accuracy and thoroughness in data collection and analysis;<br>innovation and appropriateness of the mathematical model;<br>quality and feasibility of the model predictions.<br>Clarity and persuasiveness of the presentation.<br>Team collaboration and dynamics. |
| **Key Competences** | Research and analytical skills<br>Mathematical proficiency in environmental applications<br>Strategic planning and project management<br>Effective communication and presentation skills<br>Teamwork and collaboration |
| **Connections with Eco STEAM** | Eco: Understanding and addressing the environmental impacts of human activities through mathematical analysis.<br>Science: Applying scientific principles to analyze and solve environmental problems.<br>Technology: Utilizing digital tools and software for data analysis and modelling.<br>Engineering: Designing and validating mathematical models to address environmental challenges. Arts: Creating engaging presentations and visualizations to communicate findings.<br>Math: Using data analysis, statistical methods, and mathematical models to support environmental solutions. |
| **References** | www.environmentalmath.org |
| **Notes** | This activity can be extended into a longer-term project, where students continuously develop and refine their mathematical models based on ongoing research and feedback. |

**Evaluation Criteria Table for Analyzing Environmental Impact Using Mathematical Models Activity**

| Evaluation Criteria | Points Available | Comments |
|---|---|---|

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| | | |
|---|---|---|
| **1. Accuracy and Thoroughness in Data Collection and Analysis** | 20 | Assess the precision and comprehensiveness of the data collected and analyzed. |
| **2. Innovation and Appropriateness of the Mathematical Model** | 20 | Evaluate the creativity and suitability of the mathematical model developed to address the environmental issue. |
| **3. Quality and Feasibility of Model Predictions** | 20 | Rate the reliability and practicality of the model's predictions and solutions. |
| **4. Clarity and Persuasiveness of Presentation** | 20 | Rate the clarity, persuasiveness, and professionalism of the presentation. |
| **5. Team Collaboration and Dynamics** | 20 | Assess the level of teamwork, including communication, cooperation, and mutual support among team members. |

**Total Points:** 100

| **2.4.4. ACTIVITY PLAN: FLOWER AND TREE POTS** | |
|---|---|
| **Introduction part (or activity overview)** | Decoration of the school building with flowerpots. Planting trees in the school yard or soil surfaces around the school. We know that trees and plants produce oxygen, but just how much do they? There are actually a few different factors to determine this.<br><br>Through this activity, the students engage in environmental education and math skills in designing flowerpots, create positive relationships with the environment in the school and develop positive attitudes toward the school's surroundings. Also, students are empowered to implement the knowledge they gain in school for good purposes. |
| **Setting** | Classroom and outdoor work in a schoolyard (depending on the weather conditions) |
| **Materials Needed** | Computer (phone or tablet can be used to collect information, to do some calculations), projector (to present works), recycling materials for the pots which can be reused, tools like hoes and spades for the planting, nails, pins and ropes for hanging the pots on the walls for using more space and to use the space rationally, water, and soil for the planting, natural fertilizers. |
| **Learning Outcomes** | • Gain a deeper understanding of different plant oxygen production<br>• Develop critical thinking and selfcare<br>• Learn to search, investigate and calculate for the amount of oxyden that will be produced through the years<br>• Acquire interdisciplinary knowledge<br>• Increase the ecological awareness<br>• Learn how to organize the space |
| **Activity Contents** | **Activity: Flower and tree pots**<br>**Theoretical Part (Duration: 45 minutes)**: Discuss the importance of photosynthesis for life on |

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the planet. Analyze what flowerpots are mostly made of. Present how certain resources can be used for unique designs. Discuss the math behind the creation of the pots using derivatives of functions and Geogebra applications.

**Task 1 (Duration: 20 minutes)** Students research the production of oxygen and connect it with biology and the process of photosynthesis. Students research scientific facts for the process and come up with interesting facts for the other listeners of this activity. Students calculate the usage of CO2 and the production of oxygen.
Short videos about the process:
Oxygen is liberated during Photosynthesis Practical Experiment (youtube.com) (Duration: 3:38) Overview: Explanation of the main concepts of photosynthesis and the release of oxygen from that process in exchange for carbon dioxide.

**Task 2 (Duration: 90-120 minutes)** Collect information about the techniques and types of materials used for the pot's creation. Students start developing the pots design, either by hand or using design software, aiming to ensure stable construction of pots.
Schoolchildren, working in larger groups, make plant pots for the hall of the school or the schoolyard. (If the pots are made for the school's yard the students will have to take in account all the weather conditions throughout the year):

- Each group examines one type of material used for the pots (e.g. wood, bamboo, coconut husks, natural fabrics etc.)
- Each student in the group has an assigned role (e.g., group leader and supervisor, data collector, data analyst, environmental impact predictor, speaker and presenter, everyone who works on the product etc.).

Students make plans about planting trees in specific areas around the school, it's good if this is a place where students spend time during break between classes. They choose the shape of the soil, research the types of flowers and trees that produce more oxygen than others and should be aware of the adaptation of the trees (climate changes in the country).

For the choice of trees and flowers:
www.fnp.com/article/top-9-plants-that-provide-oxygen
https://www.ugaoo.com/blogs/gardening-basics/how-many-plants-provide-oxygen-to-one-person (Suggestion, the type of trees and flowers depends on the funds needed to provide them, so give the freedom to students to choose the type of plants they can provide or have it in the schoolyard and they can multiply them with some interesting botanical techniques and skills.)

For the choice of materials for pots: https://ecofriendlyguides.com/
https://www.gardenersworld.com/

**Task 3 (Duration: 30 minutes)** Presentation of methods used for the minimum materials and volume of the pots and the hall space.

- -Students practice their presentation skills and prepare to articulate the intentions and merits behind their pot's design. Then they present their designs to the class, explaining their design choices, math objectives, and intended benefits from the idea.
- Students provide constructive criticism and suggestions for improvement on each other's designs.
- Students discuss what they learned from the process and reflect on the potential impact of their design of pots.

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| | • Students clean up their workspaces, organize their materials, and discuss what to do with the waste and excess materials.<br><br>**Additional Tips**<br>Questions that will help students with their research:<br><br>1. Evaluate the area of the field necessary for the planting actions, also to make calculations about the quantity of produced oxygen in the upcoming period.<br>2. Analyze the ways of supply of young tree seedlings (types of trees) and transportation to the school, types of soil and natural fertilizers necessary for the plants, analysis of eco systems and their cohesion.<br>3. Analyze the impact on the environment and the people who spend time in the surroundings.<br>4. Evaluate the best-generated area for planting the trees.<br>5. Prepare presentations (posters) and present them to classmates (or between classes). |
| **Assessments** | The teacher evaluates the student's work and achievements through:<br>• Verbal feedback during class;<br>• Conversation with/among students;<br>• Monitoring of students during individual and group work.<br>• Observation of the individual contribution of each student when working in groups<br>• Evaluation of students' presentations<br>• Highlighting the most<br><br>The final score is evaluated with a grade. It is possible to involve all students in the class in the assessment. Each student self-assesses his contribution to the work. After the presentations, students can have a competition about the best-made pots designed with online voting and questionnaires. |
| **Key Competences** | • Cognitive competence<br>• Creativity competence<br>• Communication competence<br>• Social, emotional and healthy living competencies<br>• Citizenship competence<br>• Digital competence<br>• Cultural competence |
| **Connections with Eco STEAM** | **Eco -** Ecological awareness about the need for forestation of fields and more green areas around us.<br><br>Science - Knowledge of biology, and geography about different types of plants and soil<br>Technology - The use of special mobile applications or computer software to create the pots and to generate the area for green plants and flowers.<br>Engineering - Through creativity, the students have to create the best area with the best options of trees, and they will have to design the space in and out of the school building.<br>Art - From a bird's eye view or oblique perspective, the planted area should be interesting and beautiful for the human eye.<br>Math - Calculation of the area for planting, the volume of used soil for the flowers and |

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| | choosing the best shape for this, assessment of cost-effectiveness, mathematical models about oxygen production, perform mathematical calculations to find out about the enormous emission of carbon dioxide and the need for oxygen on the planet Earth. |
| **References** | • Academic and scientific literature on botany, types of soil and care for the flowers.<br>• Literature for the biological processes throughout the implemented activities. |
| **Notes** | • The activity should be adaptable to different local ecosystems and weather conditions.<br>• Encouraging students to think about their future role in designing and shaping the space in which they live and work. |

**Assessment Table for Web Quest Reports:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Depth of Research** | _/5 | |
| **Understanding of different plants or flower role** | _/5 | |
| **Understanding of different soil role** | _/5 | |
| **Quality of Presentation** | _/5 | |
| **Use of types of materials** | _/5 | |

**Assessment Table for Group Presentations:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Comprehensiveness of Findings** | _/5 | |
| **Clarity in Presentation of Data (Calculations)** | _/5 | |
| **Understanding of pots design** | _/5 | |
| **Ecological Interpretations and Insights** | _/5 | |
| **Teamwork and Collaboration** | _/5 | |

| **2.4.5. ACTIVITY PLAN: OPTIMIZING AREA AND PERIMETER IN RECTANGULAR SHAPES** | |
|---|---|
| **Introduction part (or** | This session is designed to deepen students' understanding of applying the rules for |

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|---|---|
| **activity overview)** | determining extreme values of a function with the help of derivations in tasks from the fields of natural sciences, ecology and technology. The activities direct students to perceive the dependence between the quantities that change and to be able to solve problems by applying the maximum and the minimum in practical examples from life, specifically in understanding the relationship between the area and perimeter of rectangles and learning how to maximize the area while minimizing the perimeter through various hands-on activities, thereby developing critical thinking, making independent decisions and feeling useful to society through their work. |
| **Setting** | Classroom |
| **Materials Needed** | Computers with GeoGebra computer program, video presentation equipment, paper, markers. |
| **Learning Outcomes** | • Understanding the application of derivatives in finding extreme values of a function;<br>• Defining a maximum and minimum problem and finding a way to solve it;<br>• Understanding and application of GeoGebra computer program for solving problems with maximum and minimum;<br>• Understanding the application of maximum and minimum in solving environmental problems in everyday life;<br>• Solving real-world and mathematical problems involving the area and perimeter of two- dimensional objects;<br>• Application of mathematical reasoning to optimize solutions;<br>• Developing a critical opinion, independent decision-making and developing a sense of responsibility towards society. |
| **Activity Contents** | **ACTIVITY 1 (40 min): Exploring optimization using derivatives Theoretical part 1** *(15min)*<br>• Through questions, the teacher initiates the students' prior knowledge of the importance of optimization in real life. It uses examples such as maximizing the space in a room or minimizing the materials needed for a fence.<br>• The teacher explains that the most important feature of the derivative is that it lets us optimize things. Students activate their prior knowledge of applying derivatives and then they watch a video about how the extreme values of functions can be calculated using derivatives.<br><br>Video: **"Critical points and extreme values of functions"**<br>https://www.youtube.com/watch?v=dbz9g1YJ36c (duration 8 min 25 sec)<br>Overview: An educational video designed to explain what the maximum and minimum values of a function are and how they can be found using derivatives<br>*Task 1 (25 min)*<br>The students have the task of finding out what side lengths a rectangle should have in order to maximize its area, if the rectangle has a diagonal with a constant length of 2 units. To make it easier for them to come up with a hypothesis that they will have to prove, they have at their disposal an interactive applet in the GeoGebra computer program that they will work on individually. The students are given instructions about the exercise, then they independently explore the applet, complete the question sheet and, finally, self-assess **(Appendix 1)**. The following link |

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will take you to an interactive applet:

**An interactive applet 1 in GeoGebra:** https://www.geogebra.org/classic/mxkmsteh

**ACTIVITY 2 (70 min): Area optimization in real-life scenarios. Theoretical part 1** *(10min)*

The teacher explains that Optimizing areas in real life is a crucial concept in various fields such as urban planning, agriculture, architecture and environmental conservation. Of particular importance is the application of optimization with the help of derivatives in problems from everyday life. The following video shows one such example and its solution. The dimensions need to be found to maximize the fenced area, which is a rectangular region where one side is on a river and the required fence makes up the other three sides.

Video: **"Maximize area given perimeter (optimization)"**

https://www.youtube.com/watch?v=m3wXop8GKoc (duration: 4min 39 sec)

*Task 1 (15 min)*

Students have to design an ecological urban garden using recycled materials. They have a fixed amount of fencing material (eg. 40 meters) and must plan a rectangular garden that maximizes the planting area. The students have to find out what the dimensions of the rectangular garden should be in order for it to have the maximum area using derivatives. Students do this exercise individually. After the students have completed the required calculations, the teacher presents on the smart board the correct calculations that the students should have received, and the students compare them with their own calculations and self-evaluate.

*Task 2 (45min)*

The teacher asks students to relate optimization to environmental science by discussing examples such as maximizing crop yield while minimizing water use or minimizing waste production in production processes. Then the teacher divides the students into 4 groups and assigns each group an environmental optimization challenge.

1. The first group works on the problem of "Urban Planning"

Students should design a residential building that maximizes the usable floor space of a given area, ensuring efficient use of space for living, working and other activities. Surrounding the building there should be parks that provide maximum space for recreation while taking into account constraints such as budget and available land.

2. The second group works on the "Agriculture" problem.

The students have to design an ecological agricultural garden in which there will be greenhouses with a maximized area for cultivation while minimizing the use of materials and energy consumption. In addition to them, there should be agricultural fields with an optimized surface area to maximize crop yields. This includes strategically placing crops to ensure they receive adequate sunlight and water.

3. The third group works on the problem of "Renewable energy sources"

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| | Students should design Wind Farms in which wind turbines will be placed in such a way as to optimize land use and ensure efficient capture of wind energy, taking into account the spacing required to prevent turbulence. They can also set Solar farms to maximize the area covered by solar panels, increasing energy production, while taking into account factors such as sunlight exposure and land availability.<br><br>4. The fourth group works on the problem "Personal Spaces".<br>Students have to design a family house by optimizing the layout of the home to make the best use of the available space for living, storage and recreational purposes. Around the house to design a garden to maximize the area for planting flowers, vegetables and recreational spaces, while taking into account aesthetic appeal and functionality.<br><br>Students can make the sketches partially or completely in a computer program or on a flip chart using markers. Students working in groups should develop solutions and mathematical models for the problems they are working on and finally, they should present their findings to the class noting that by understanding and applying area optimization techniques, we can create more efficient, sustainable and functional spaces in a variety of real-life scenarios. Students can use optimization apps and other digital resources.<br>While the students are working through the exercises, the teacher walks around the classroom to provide help and guidance as needed.<br><br>*Discussion and reflection (5 min.)*<br>● Students review optimization using derivations and highlight its real-world application.<br>● The importance of considering environmental factors in the design of buildings with an optimal area is emphasized.<br>● Students highlight the connection between mathematics and environmental sustainability.<br>● The teacher awards an environmental award to the group that demonstrated the most creativity, cooperation and problem-solving skills during the activity, chosen as the best of the entire class. |
| **Assessments** | Verbal feedback during class;<br>Conversation with/among students;<br>Monitoring of students during group work;<br>Evaluation of the thoroughness and accuracy of individual work;<br>Each student self-assesses his contribution to the work. |
| **Key Competences** | ● Cognitive competence<br>● Creativity competence<br>● Communication competence<br>● Social, emotional and healthy living competencies<br>● Digital competence |
| **Connections with Eco STEAM** | **Eco** - By integrating eco-friendly themes and real-world applications into the study of optimization with derivatives we can create more efficient, sustainable, and functional spaces in various real-life scenarios. |

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| | Science - Students will learn how mathematical optimization can help design eco-friendly spaces, like community gardens, wildlife habitats, and green spaces, which are crucial for maintaining biodiversity and promoting environmental health.<br>Technology—Students will use GeoGebra computer programs to simulate and solve mathematical problems and design software (CAD, GIS) to create and visualize optimized layouts.<br>Engineering - Students will see how engineering principles are used to design environmentally efficient structures.<br>Art - Students will use their artistic abilities in creating and designing projects.<br>Math - Students will use mathematical models and simulations for area optimization and apply derivations in solving optimization problems |
| **References** | • Mathematics textbook for high school education in the Republic of Nort Macedonia<br>• https://www.geogebra.org<br>• videos with a link given above in the text |
| **Notes** | • Students can think of additional optimization problems related to environmental conservation and sustainability, which they can further investigate on their own.<br>• Encourage students to think about how mathematical concepts can be applied to solve real-world challenges and emphasize the interdisciplinary nature of STEAM education.<br>• Through these activities, students develop problem-solving skills and critical thinking abilities. |

## APPENDIX 1 . STUDENT'S ACTIVITY SHEET

| **Explore the applet and answer the following questions:**<br>Name and surname: | |
|---|---|
| 1. In the applet, a rectangle is drawn with a constant diagonal of length 2 units and sides that change by moving point A. Observe the value of the area visible on the applet at different values of the sides of the rectangle, and record several values in the table on the right. What do you notice? | |
| 2. Write your guess about what dimensions the rectangle should have in order to maximize its area<br>(Then, click the box before the word " hypothesis" to compare your hypothesis with the applet's hypothesis) | |
| 3. Using the rules for finding extreme values using derivations, prove the hypothesis of the applet | |
| 4. What will be the maximum area of the rectangle whose diameter is 2 units? | |

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| After answering the questions, compare your answer and the proof of the hypothesis with the answer you will find on the<br>applet by clicking on the appropriate box and with the help of the questions that follow, evaluate your achievements in this exercise: | | | | | |
|---|---|---|---|---|---|
| How well did you understand how the applet works? | 1 | 2 | 3 | 4 | 5 |
| How do you evaluate your ability to independently research and come up with a hypothesis? | 1 | 2 | 3 | 4 | 5 |
| How do you rate your knowledge of solving extreme value problems using derivations? | 1 | 2 | 3 | 4 | 5 |
| How satisfied are you with your own engagement in mastering new material? | 1 | 2 | 3 | 4 | 5 |

**Assessment Table for individual work:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Understanding optimization using derivatives** | _/10 | |
| **Understanding a real-life problem and setting a mathematical problem** | _/5 | |
| **Digital skills at work in the interactive applet** | _/5 | |
| **Application of derivatives in finding the maximum area** | _/10 | |
| **Recognition of optimization problems related to environmental conservation and sustainability** | _/5 | |
| **Solving a problem and making a conclusion** | /5 | |

**Assessment Table for group work:**

| Assessment Criteria | Points | Comments |
|---|---|---|
| **Understanding the environmental Optimization challenge.** | _/5 | |
| **Application of mathematical models in solving area optimization problems** | _/5 | |

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| **Skills of presenting the work** | _/5 | |
| **Ecological Interpretations and Insights** | _/5 | |
| **Teamwork and Collaboration** | _/5 | |
| **Skill and creativity in project design** | _/5 | |

| **2.4.6. ACTIVITY PLAN: USING MATHEMATICS FOR ENVIRONMENTAL MODELING AND ANALYSIS** | |
|---|---|
| **Introduction part (or activity overview)** | This activity aims to demonstrate the critical role of mathematics in understanding and solving environmental problems through modeling and analysis. Students will use mathematical concepts and tools to analyze environmental data and create models that can predict and address environmental issues. |
| **Setting** | Location: Classroom and computer lab for research and analysis.<br><br>Educational Context: Collaborative group work (4-5 students per group). |
| **Materials Needed** | Computers with internet access and relevant software (e.g., spreadsheets, mathematical modeling tools)<br>Access to online data sources for environmental statistics<br>Projector for presentations<br>Graph paper, calculators, and other mathematical tools |
| **Learning Outcomes** | ● Understand the role of mathematics in environmental modelling and analysis.<br>● Develop skills in data collection, analysis, and mathematical modelling.<br>● Enhance abilities in research, project development, and presentation |
| **Activity Contents** | **Theoretical Part (Duration: 45 minutes)**: Begin with an introduction to the significance of mathematics in addressing environmental issues. Highlight various mathematical methods and tools used in environmental analysis.<br>● **Introduction to Environmental Mathematics**:<br>o Discuss the application of statistical methods, differential equations, and computational models in environmental science.<br>o Explore case studies where mathematical modelling has successfully addressed environmental challenges.<br>● **Video Resources**:<br>o " Environmental Science track - Math & Science Institute " https://www.youtube.com/watch?v=S4fTX8kMgKI – A video showcasing the role of mathematics in environmental science and its applications.<br><br>**Task 1: Data Collection and Analysis (Duration: 45 minutes) Objective**: To collect and |

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| | analyze environmental data using mathematical tools.<br>• **Step 1**: Form groups and assign each group a specific environmental parameter to study (e.g., air quality, water quality, temperature changes).<br>• **Step 2**: Use online data sources to collect historical data on the assigned parameter.<br>• **Step 3**: Input the data into a spreadsheet or mathematical software to analyze trends, patterns, and anomalies.<br>• **Step 4**: Use statistical methods to interpret the data and draw conclusions.<br>**Task 2: Mathematical Modeling (Duration: 90 minutes) Objective**: To create a mathematical model that predicts future environmental conditions based on collected data.<br>• **Step 1**: Based on the data analysis, develop a mathematical model using relevant methods (e.g., regression analysis, differential equations).<br>• **Step 2**: Use the model to predict future values of the environmental parameter under different scenarios (e.g., increased pollution, climate change mitigation efforts).<br>• **Step 3**: Validate the model by comparing its predictions with actual data and adjust as necessary.<br>• **Step 4**: Prepare a presentation summarizing the data analysis, model development, predictions, and potential solutions based on the model.<br>**Task 3: Presentation and Feedback (Duration: 45 minutes) Objective**: To present the mathematical model and analysis to the class and receive feedback.<br>• **Step 1**: Each group presents their data analysis, mathematical model, and predictions to the class.<br>• **Step 2**: Conduct a Q&A session where other students and the instructor can provide feedback and ask challenging questions.<br>• **Step 3**: Groups reflect on the feedback received and discuss potential improvements. |
| **Assessments** | Accuracy and thoroughness in data collection and analysis;<br>innovation and appropriateness of the mathematical model;<br>quality and feasibility of the model predictions.<br>Clarity and persuasiveness of the presentation.<br>Team collaboration and dynamics. |
| **Key Competences** | Research and analytical skills<br>Mathematical proficiency in environmental applications<br>Strategic planning and project management<br>Effective communication and presentation skills<br>Teamwork and collaboration |
| **Connections with Eco STEAM** | Eco: Understanding and addressing environmental issues through mathematical analysis.<br>Science: Applying scientific principles to analyze and solve environmental problems.<br>Technology: Utilizing digital tools and software for data analysis and modelling.<br>Engineering: Designing and validating mathematical models to address environmental challenges. |

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| | Arts: Creating engaging presentations and visualizations to communicate findings.<br>Math: Using data analysis, statistical methods, and mathematical models to support environmental solutions. |
| **References** | www.environmentalmath.org |
| **Notes** | This activity can be extended into a longer-term project, where students continuously develop and refine their mathematical models based on ongoing research and feedback. |

**Evaluation Criteria Table for Using Mathematics for Environmental Modeling and Analysis Activity**

| Evaluation Criteria | Points Available | Comments |
|---|---|---|
| **1. Accuracy and Thoroughness in Data Collection and Analysis** | 20 | Assess the precision and comprehensiveness of the data collected and analyzed. |
| **2. Innovation and Appropriateness of the Mathematical Model** | 20 | Evaluate the creativity and suitability of the mathematical model developed to address the environmental issue. |
| **3. Quality and Feasibility of Model Predictions** | 20 | Rate the reliability and practicality of the model's predictions and solutions. |
| **4. Clarity and Persuasiveness of Presentation** | 20 | Rate the clarity, persuasiveness, and professionalism of the presentation. |
| **5. Team Collaboration and Dynamics** | 20 | Assess the level of teamwork, including communication, cooperation, and mutual support among team members. |

**Total Points:** 100

| **2.4.7. ACTIVITY PLAN: THE SIMPLEST DIMENSIONLESS CLIMATE MODEL** | |
|---|---|
| **Introduction part (or activity overview)** | This activity is designed to deepen students' understanding of the greenhouse effect. We will create the simplest zero-dimensional climate model. Though this model is very basic, it can be used to explore how changes in solar irradiance, albedo, and emissivity could affect Earth's temperature.<br><br>Using the GeoGebra software, students will prepare a mathematical model of the energy balance that will allow them to perform calculations, visualize data, and experiment with the given data. |
| **Setting** | Classroom |

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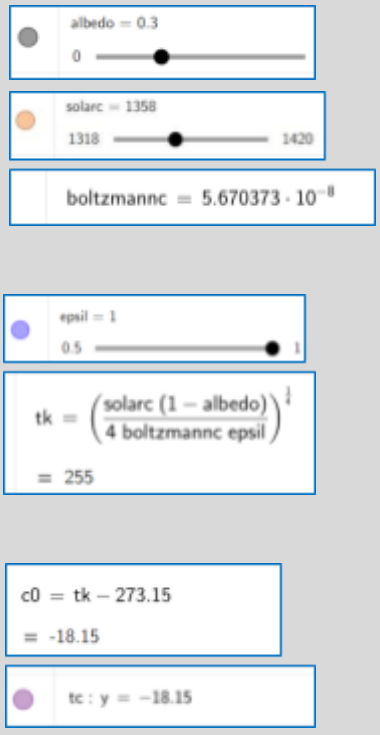
| **Materials Needed** | Computers (tablets) connected to the internet, GeoGebra software, pen, and paper for notes. |
| **Learning Outcomes** | Students will improve their understanding of the greenhouse effect.<br>They will get acquainted with the simplest zero-dimensional climate energy balance model.<br>They will examine the Stefan-Boltzmann law and will be able to express the parameter T from the Stefan-Boltzmann law. Using the GeoGebra program, they will perform the input of the Stefan-<br>Boltzmann formula and the creation of parameter sliders (slider tool), write down the function, and formulate conclusions. |
| **Activity Contents** | **Activity 1:**<br>**Theoretical Part (Duration: 15 minutes):**<br>After watching the designated video, students will become familiar with the structure of the climate energy balance model and understand the Stefan-Boltzmann law. They will note down the derived formula and the possible values of the parameters (constants) used in the formula.<br>**Video:**<br>https://www.youtube.com/watch?app=desktop&v=zvgQ6exOklg<br>Duration: Approx. 11 minutes<br>**Task (**Duration: 25 minutes):<br>Working in pairs or individually, using the Slider Tool in GeoGebra, students will create sliders for the values of parameters and constants. In GeoGebra, they will enter the expression for the parameter T (temperature) from the Stefan-Boltzmann law, using the symbols of already entered constants and parameter coefficients. They will write a function y that expresses the temperature in Kelvin (K) in<br>degrees Celsius (°C). Using the animation of the Slider Tool, they will investigate the dependency of temperature on albedo, the solar constant, and an additional parameter ε (atmospheric absorption).<br>Model Creation Process (recommendations) in the GeoGebra environment: (https://www.geogebra.org/):<br>  |

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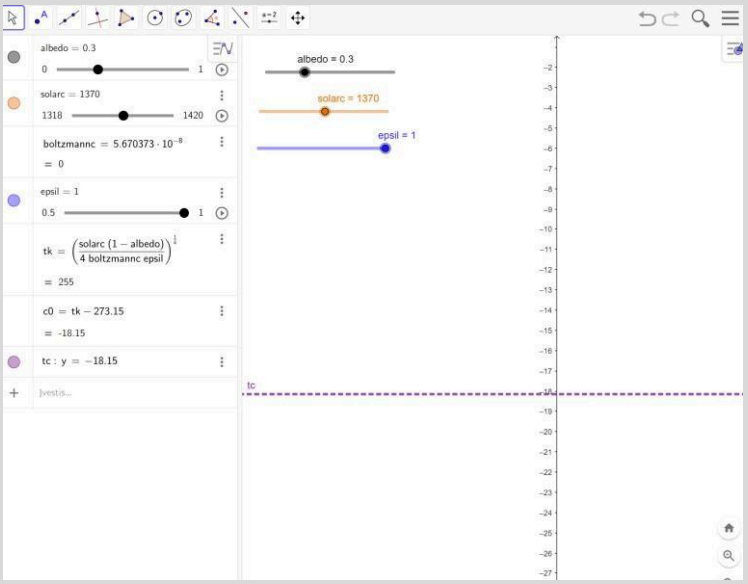
| |  <br>Summary, Conclusions (Duration: 5 minutes)<br>By changing the parameters, students will test the model's operation and formulate conclusions:<br>• The dependency of temperature on albedo,<br>• The dependency of temperature on the solar constant,<br>• Why does the greenhouse effect occur? |
| **Assessments** | The activity is evaluated as indicated in Appendix 1. |
| **Key Competences** | • Cognitive competence<br>• Creativity competence<br>• Digital competence |
| **Connections with Eco STEAM** | Eco – The impact of Earth's albedo decrease on the greenhouse effect.<br><br>Science - The creation process can encourage interdisciplinary learning (physics, geography, mathematics).<br>Technology - Integrating technologies allows for the visualization of climate models and mathematical formulas.<br>Engineering - Investigation by changing the parameters in the formula. Art - Symmetry in mathematics.<br>Math - Derivation and rearrangement of formulas. Writing mathematical formulas in the GeoGebra environment. |
| **References** | https://denning.atmos.colostate.edu/ats150/lectures/04.LayerModel.pdf<br>https://llis.nasa.gov/lesson/693<br>https://physics.nist.gov/cgi-bin/cuu/Value?sigma<br>https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100530577 https://www.geogebra.org/ |
| **Notes** | The process of model creation (recommendations) in the GeoGebra program can be provided to students who may encounter difficulties working with this software. Advanced students can create the model without recommendations (choosing parameter notations, |

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## APPENDIX 1

**Evaluation and Self-Evaluation Table:**

| Evaluation criteria | Points | Comments |
|---|---|---|
| **Writing the required formula, and notation of constants from provided sources** | _/2 | For correct notation of the formula, find the values of the required constants from sources. |
| **Use of the GeoGebra tool: the creation of sliders, the input of formula, writing the temperature function** | _/4 | For the application of the GeoGebra tool:<br>1. creation of sliders, input of formula,<br>2. setting the ranges for constants,<br>3. the input of the formula t (temperature),<br>4. writing the function y (degrees conversion from K to °C). |
| **Demonstration of the investigation process** | _/2 | For the demonstration of the model, i.e., the movement of function y along the Y-axis. |
| **Formulation of conclusions** | _/2 | For correctly formulate two conclusions. |

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