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| Activity plan | | | | |
| ACTIVITY PLAN | | | | |
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| **Theme** | **Subtopic** | **Activity Title** |
| 2. STEAM Integration in Environmental Education | 2.4. Mathematics in Environmental Modeling and Analysis | Optimizing Area and Perimeter in Rectangular Shapes |

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| Introduction part (or activity overview) |
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| **Introduction part (or activity overview)** | This session is designed to deepen students’ understanding of applying the rules for determining extreme values of a function with the help of derivations in tasks from the field 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 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 |

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| Materials Needed |
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| **Materials Needed** | Computers with GeoGebra computer program, video presentation equipment, paper, markers. |

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| **Learning Outcomes** | * Understanding the application of derivatives in finding extreme values ​​of a function; * Defining a maximum and minimum problem and finding a way to solve it; * Understanding and application of GeoGebra computer program for solving problems with maximum and minimum; * Understanding the application of maximum and minimum in solving environmental problems in everyday life; * Solving real-world and mathematical problems involving the area and perimeter of two-dimensional objects; * Application of mathematical reasoning to optimize solutions; * 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)*   * 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. * 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.   Video: **“Critical points and extreme values of functions”**  <https://www.youtube.com/watch?v=dbz9g1YJ36c> (duration 8 min 25 sec)  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  *Task 1 (25 min)*  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 will take you to an interactive applet:  **Аn 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 оptimizing 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 "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.   1. 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.   1. The third group works on the problem of "Renewable energy sources"   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.   1. The fourth group works on the problem "Personal Spaces".   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.  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.  While the students are working through the exercises, the teacher walks around the classroom to provide help and guidance as needed.  *Discussion and reflection (5 min.)*  • Students review optimization using derivations and highlight its real-world application.  • The importance of considering environmental factors in the design of buildings with an optimal area is emphasized.  • Students highlight the connection between mathematics and environmental sustainability.  • 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;  Conversation with/among students;  Monitoring of students during group work;  Evaluation of the thoroughness and accuracu of individual work;  Each student self-assesses his contribution to the work. |
| **Key Competences** | * Cognitive competence * Creativity competence * Communication competence * Social, emotional and healthy living competences * 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.  **S**cience: 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.  **T**echnology: Students will use GeoGebra computer programs for simulation and solving mathematical problems and design software (CAD, GIS) for creating and visualizing optimized layouts.  **E**ngineering: Students will see how engineering principles are used to design environmentally efficient structures.  **A**rt: Students will use their artistic abilities in creating and designing projects.  **M**ath: 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 * <https://www.geogebra.org> * 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.  • Encourage students to think about how mathematical concepts can be applied to solve real-world challenges and emphasize the interdisciplinary nature of STEAM education.  • Through these activities, students develop problem-solving skills and critical thinking abilities. |

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| Appendix 1 . STUDENT'S ACTIVITY SHEET |
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| Explore the applet and answer the following questions:  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  (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? | |  | | | | |
| Аfter answering the questions, compare your answer and the proof of the hypothesis with the answer you will find on the 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:**

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| 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 |  |
| Аpplication 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:**

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| Assessment Criteria | Points | Comments |
| Understanding the еnvironmental оptimization challenge. | \_\_/5 |  |
| Application of mathematical models in solving area optimization problems | \_\_/5 |  |
| Skills of presenting the work | \_\_/5 |  |
| Ecological Interpretations and Insights | \_\_/5 |  |
| Teamwork and Collaboration | \_\_/5 |  |
| Skill and creativity in project design | \_\_/5 |  |