LESSONS 9-12

Aim of the cycle

To create conditions for students to develop their engineering competence by creatively solving engineering problems, to develop the ability to apply scientific and technological knowledge in creating, designing and implementing engineering products, systems, processes and solving the challenges faced by the public.

Objectives of the cycle

The objectives for students are:

- develop engineering skills in combining engineering, technological, artistic and social skills, creating a harmonious and sustainable environment;
- develop critical thinking, practical and creative activity skills, and apply them to solve various real environmental and sustainable development problems;
- create and design engineering processes and systems, apply science and technology knowledge and skills through interdisciplinary engineering projects;
- develop the ability to creatively apply theoretical and practical knowledge of design, layout, photography, film, image manipulation, visualization in integral projects, their presentations;

Topic of the lesson. How engineering ideas are born and how they travel

Methods

Demonstration; use of presentations and / or digital learning objects; brainstorming; understanding students' experience; discussion; mutual teaching/ learning; storytelling, reading; demonstration and discussion of filmed material; group works; presentations; (self) assessment; questions for reflection.

Materials

Presentations, educational presentation, worksheets, examples of engineering creative works, computers, internet access, programing equipment - QCAD (or Adobe Illustrator, Corel Drow, SketchUP, Paintnet or others), programming equipment - Autodesk 123D Design (or Blender, Autodesk Fusion 360, SolidWorks, Autodesk Inventor, SketchUP, MAYA, Autodesk 3DS Max or others), Cura (or SIMPLIFY 3D, Slic3r, Microsoft 3D Builder or others), he website microbit.org., micro:bit controllers, ultimaker 2/ 2+ 3D printer (or another regarding the needed parameters), material for 3D printing (3 mm, 60 g (1 unit), PLA filament, photo, video equipment, paper of various types (or other constructive material), printing paper, scissors, paper cutter knives, rulers and other materials for implementing projects, discussed with students in advance.

Objectives of lessons

- **9 lesson**

After getting acquainted with the history, working individually and in groups:
- analyze the history and raise hypotheses/ ideas (1-3) how the problems might be solved;
- perform the task in groups and provide ideas (1-2) why and how to improve soil conditions or how to improve air quality;
- present and discuss your prepared works.

- **10-11 lessons**

After having analyzed engineering tasks and information found in the worksheets, you will choose which problems (1st or 2nd task) you will solve; join (form) teams; organize the work in order to fulfil all conditions of the chosen task; prepare for presenting the project.

- **12 lesson**

After having discussed the ways and rules of presenting projects, you will present and (self) assess yours and other groups' project works according to the discussed criteria.

LESSONS 9-12

Content

Chemistry and Bioengineering. Examples of problems solved by chemistry and bioengineering. Assessment of the use of natural resources and possibilities in engineering. Investigation of chemical processes and materials' properties, interpretation of practical application possibilities in solving engineering problems. Food research and food analysis. Investigation of materials degradation (eg corrosion, decay), investigation of the practical application of possible anti-degradation measures, selection. Customizable products and simulation of their production. Examples of biological products and their use in agricultural engineering, environmental effects.

Energy Engineering. Variety of energy types and analysis of possibilities for utilization for human needs. Examples of solving basic energy engineering problem, analysis. Analysis of mathematical concepts, models, methods and relationships applied to solving energy engineering problems, calculations. Analysis of energy loss problem and engineering solutions. Examples of elemental heat production systems. Analysis of problems solved by electronics and electrical engineering. Examining the principles of operation of modern electronic systems, analysis of practical applications in engineering. Application of energy regularities, examples of their application in the management of engineering (energy, mechanical engineering, bioengineering, etc.) processes and engineering elements.

Design and Civil Engineering. Examining urban object design and building engineering achievements. Examples of architectural design, spatial planning in urban engineering, research. Application of mathematical calculations in the design of engineering elements. Graphic, environmental objects, industrial design, analysis of their specifics and peculiarities of application. Planning and implementation of design processes and solutions. Natural element modeling and engineering application.

Computer Engineering. Construction of selected objects with computer tools, creation, editing, management and application of computer objects. Data formats. Discussion of the presentation rules and practical application in engineering. Object adaptation for various media formats. Creating a logical structural presentation, demonstration. Simulation computer programs. Creation and application of building and dynamic elements . Preparing for presentations and presentation of engineering solutions and opportunities. Preparation of objects for media and audiovisual engineering.

Media and Audiovisual Engineering. The unity and harmonization of technology, cultural content and artistic expression. Research on contemporary media and design innovations (e.g., iPod, iPad phenomena, etc.). Contemporary media works / presentations / advertisements as developed by technological means.

Engineering History and Philosophy. Examples of contemporary research and engineering solutions. Analysis of engineering and environmental problems, analysis of their solution possibilities. Getting to know engineering hypotheses, test values and engineering. Analysis of engineering and environmental problems, analysis of their solution possibilities. Discussion and analysis of major engineering mistakes. The main ethical provisions and evaluation of engineering. Argumentative discussion on the basic principles of engineering science, the ethical principles of engineering, and the impact of engineering science on human development. Discussion on social issues, the decisions which involve engineering. Introduction to the prehistory of engineering and the history of engineering. Description and interpretation of interdisciplinary problem in engineering disciplines. Investigation of engineering thinking and practical interaction. Discussion of the main issues of engineering science (characteristics and purpose of the engineering product, interaction with the user and the external environment).

Engineering Process Modeling, Management, Business and Economics. Resources for engineering products. Project budget and its calculation. Project financing opportunities. Analysis of product demand and supply.

LESSONS 9-12

Activities

Lesson 9

1. ACTIVITY. PRESENTING THE TOPIC. INTRODUCTION TO THE ENGINEERING TASK (45 MIN.)

1.1. Discussion (5 min.)

Suggestions for discussion

Let us remember what we learned and found out about engineering.

What surprised you the most?

Summarizing: we found out and learned a lot of new things applying the acquired knowledge/ skills to solve engineering problems.

1.2. Announcing the topic of a lesson and discussing the aim and the objectives (2 min.)

Cycle 4

IDEA OF SUSTAINABLE DEVELOPMENT— CHALLENGE FOR SCIENCE AND ENGINEERING. Duration of the cycle – 4 lessons

(more Cycle 1. Objectives)

1.3. Storytelling (warming-up activity) (4 min.)

Students read the story *Lessons No. 9-12. Appendix No. 1. Story.*

Lessons No. 9-12. Appendix No. 1. Story

1.4. Announcing the topic of the lesson and raising objectives (2 min.)

Topic

How engineering ideas are born and how they travel

The objectives of the lesson are raised and discussed.

Objective

After getting acquainted with the history, working individually and in groups:

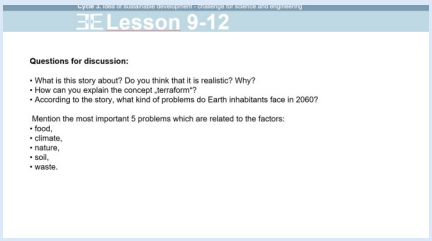
- analyze the history and raise hypotheses/ ideas (1-3) how the problems might be solved;
- perform the task in groups and provide ideas (1-2) why and how to improve soil conditions or how to improve air quality;
- present and discuss your prepared works.

Tip for the teacher

•Get students interested by allowing them see the benefits, necessity, success in dealing with the information which will be taught/ learned; think about what, how and why they were studying in the previous lesson.

1.5. Analysis of the text (6 min.)

Presentation *Lessons No. 9-12. Appendix No. 2. Questions for discussion.*



Lessons No. 9-12. Appendix No. 2. Questions for the discussion

Questions for discussion:

1. What is this story about? Do you think that it is realistic? Why?
2. How can you explain the concept „terraform"?

ⓘ useful information

3. According to the story, what kind of problems do Earth inhabitants face in 2060? Mention the most important 5 problems which are related to the factors:
   - food,
   - climate,
   - nature,
   - soil,
   - waste.

Tip for the teacher
• During the discussion specific questions might be asked in order to get the right answers from students.

Recommendation

While discussing responses moderate consumption; collection and composting of biodegradable waste of organic origin; various sorting and recycling of waste; the importance of "environmentally friendly" energy sources should be emphasized.

Tip for the teacher
• *Explain what hypothesis and problem mean.*

1.6. Task– recognizing/ identifying of engineering problems. Raising hypotheses (18 min.)

Question for discussion:

- What should be done today in order to have a better future?

Possible ideas/ hypotheses about: *food, climate, nature, soil, waste, etc.*

Tips for the teacher
• *It is recommended to give one task for each pair/ group of students.*
• *If students identified other problems or raised other hypotheses— perform tasks after having discussed them with students.*
• *It might be suggested for students to use available resources (e.g. mobile phones, computers with internet access, etc.)*

Task

Students are suggested to complete the tasks in pairs/groups:

Possible tasks:

1. Why do we need to improve soil condition? How can this be done?
2. How can air quality be improved?

LESSONS 9-12

1.7. Presentations and discussion (8 min.)

Pairs/groups of students present their completed tasks.

Suggestions for discussion

- How engineering problems are identified and hypotheses raised, there might be several hypotheses for one problem, the interdisciplinarity of a problem, identity of place, ethical dilemmas, creativity and others are emphasized.

Lessons 10-11

2. ACTIVITY. CREATIVE ENGINEERING TASK (90 MIN.)

2.1. Reminding the topic of the lesson and raising objectives (5 min.)

Topic How engineering ideas are born and how they travel

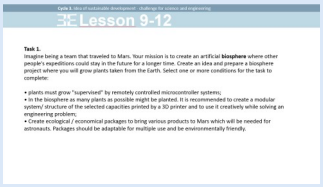
The objectives are raised and discussed.

Objective

After having analyzed engineering tasks and information found in the worksheets, you will choose which problems (1st or 2nd task) you will solve; join (form) teams; organize the work in order to fulfil all conditions of the chosen task; prepare for presenting the project.

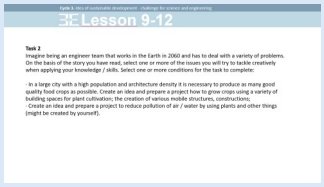
2.2. Presenting and discussing the creative task (10 min.)

Students are shown the slide *Lessons No. 9 -12. Appendix No. 3. Task 1 and the slide Lessons No. 9 -12. Appendix No. 4. Task 2.*


Lesson 9-12

Task 1.
Imagine being a team that traveled to Mars. Your mission is to create an artificial **biosphere** where other people's expeditions could stay in the future for a longer time. Create an idea and prepare a biosphere project where you will grow plants taken from the Earth. Select one or more conditions for the task to complete:

- plants must grow "supervised" by remotely controlled microcontroller systems;
- in the biosphere as many plants as possible might be planted. It is recommended to create a modular system/ structure of the selected capacities printed by a 3D printer and to use it creatively while solving an engineering problem;
- Create ecological / economical packages to bring various products to Mars which will be needed for astronauts. Packages should be adaptable for multiple use and be environmentally friendly.


Lesson 9-12

Task 2
Imagine being an engineer team that works in the Earth in 2060 and has to deal with a variety of problems. On the basis of the story you have read, select one or more of the issues you will try to tackle creatively when applying your knowledge / skills. Select one or more conditions for the task to complete:

- In a large city with a high population and architecture density it is necessary to produce as many good quality food crops as possible. Create an idea and prepare a project how to grow crops using a variety of building spaces for plant cultivation; the creation of various mobile structures, constructions;
- Create an idea and prepare a project to reduce pollution of air / water by using plants and other things (might be created by yourself).

Lessons No. 9 -12. Appendix No. 3

Students are given worksheets with tasks *Lessons No. 9 -12. Appendix No.5. Worksheet.*

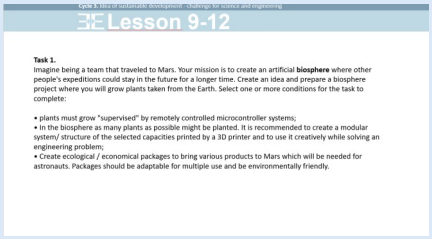

LESSON 9-12

Lessons No. 9 -12. Appendix No.5. Worksheet 1

Tips for the teacher

- *The aim and objectives are discussed with students.*
- *The students' motivation is emphasized – why we concentrate on these objectives; e.g. it is useful in everyday activities, it is interesting, etc.*
- *The objectives should be not only discussed but it also be attempted to raise them together with students.*

LESSONS 9-12



Slide *Lessons No. 9 -12. Appendix No. 3*

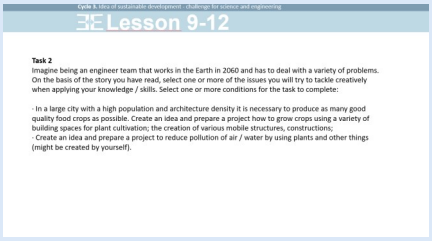
Task 1

Imagine being a team that traveled to Mars. Your mission is to create an artificial **biosphere** where other people's expeditions could stay in the future for a longer time. Create an idea and prepare a biosphere project where you will grow plants taken from the Earth. Select one or more conditions for the task to complete:

• plants must grow "supervised" by remotely controlled microcontroller systems;

• plant as many plants as possible in the biosphere (it is recommended to create a modular system/ structure of the selected capacities printed by a 3D printer and to use it creatively while solving an engineering problem);

• create ecological / economical packages to bring various products to Mars which will be needed for astronauts. Packages should be adaptable for multiple use and be environmentally friendly.



Slide *Lessons No. 9 -12. Appendix No. 4*

Task 2

Imagine being an engineer team that works in the Earth in 2060 and has to deal with a variety of problems. On the basis of the story you have read, select one or more of the issues you will try to tackle creatively when applying your knowledge / skills. Select one or more conditions for the task to complete:

- in a large city with a high population and architecture density it is necessary to produce as many good quality food crops as possible. Create an idea and prepare a project how to grow crops using a variety of building spaces for plant cultivation; the creation of various mobile structures, constructions;
- how to reduce pollution of air / water by using plants and other things (might be created by yourself), prepare the project.

LESSONS 9-12

Recommendation

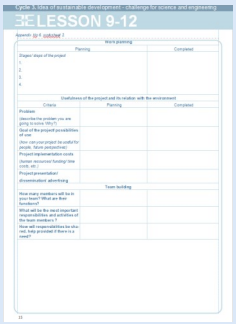
It is recommended to demonstrate students the projects created by their fellow students, e.g., films *Lessons No. 9 -12. Appendix No.9., No.10, No.11. Students' creative engineering projects*



Lessons No. 9 -12. Appendix No.9., No.10, No.11. Students' creative engineering projects

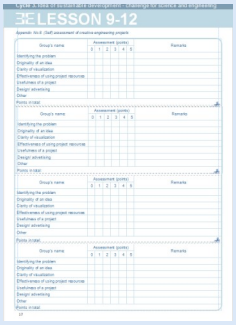
2.3. Discussion of completing the task (5 min.)

Students are given *Lessons No. 9 -12. Appendix No.6. Worksheet 2, Lessons No. 9 -12. Appendix No.7. Presentation of creative engineering works* and *Lessons No. 9 -12. Appendix No.8. (Self) assessment of creative engineering works*



Lessons No. 9 -12. Appendix No. 6. Worksheet 2

Lessons No. 9 -12. Appendix No.7. Presentation of creative engineering works



Lessons No. 9 -12. Appendix No.8. (Self) assessment of creative engineering works

Tips for the teacher

- *Encourage the students' discussion, emphasize the possibilities of engineering creation;*
- *Encourage the students, demonstrating the examples of works created by their fellow students or other examples.*

LESSONS 9-12

Students and teacher together analyze the information provided in the worksheets, the structure, discuss the criteria for completing tasks (if any suggestions are provided, they should be added to the worksheet), agree on the order of filling in the worksheet, time, etc.

It is recommended to discuss how the projects will be presented in advance. If a presentation is organized, e.g. like a business fair, conference, etc., it is important to discuss it with students.

2.4. Team formation (10 min.)

Recommendation

Think about team building for a long term assignment. Take into account the age of pupils, the peculiarities of communication, experience, abilities, etc. Discuss the specifics of completing the task (referring to the worksheet), discuss the number of team members, their duties, and other things. It is possible to decide with the students how the teams will be formed in order to avoid accidental events, for example, when the best friends are picked up for the team. Note that the composition of the team should be such that students can collaborate effectively while working and completing the task. Various human resource options are available, such as inviting / hiring another team member to perform a specific task, and so on. In this way, the students will strengthen their cooperation skills, learn different ways and strategies for communication and cooperation, and discover new traits of their character, learn tolerance, share knowledge and learn from each other.

Tip for the teacher

• Discuss the teamwork opportunities with students, recall / analyze effective methods (analytical (performance analysis, needs analysis, heuristic method and others), non-analytical (brainstorming, synectics, etc.), which will help to succeed in completing projects.

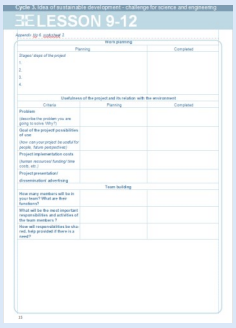
2.5. Performing the task and preparing for presentations (65 min.)

The teams are given the needed materials/ tools/ worksheets and (self) assessment sheets for completing the task.

Tips for the teacher

• If it is possible, we suggest completing the creative task during additional 1-4 lessons.

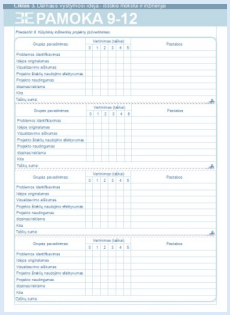
• Students might be reminded once again of the *scheme of engineering creative process (Lessons No. 6 -7. Appendix No. 1. Scheme of engineering creative process).*



Lessons No. 9 -12. Appendix No.6. Worksheet 2

Lessons No. 9 -12. Appendix No.7.Presentation of creative engineering projects

LESSONS 9-12


PAMOKA 9-12

Lesson No. 9 -12. Appendix No. 8. (Self) assessment of creative engineering projects

Lesson 12

3. PRESENTING CREATIVE ENGINEERING PROJECTS (45 MIN.)

3.1. Raising the objective (3 min.)

The objective of the lesson is raised and discussed.

Objective

After having discussed the ways and rules of presenting projects, you will present and (self) assess yours and other groups' project works according to the discussed criteria.

3.2. Presenting and (self) assessment of projects (32 min.)

The evaluation criteria of presentations are discussed with students once again, how presentations will take place (e.g. if all groups are going to evaluate presentations of other groups, or only some groups will be responsible for assessing, etc.), when questions should be posed and so on.

Time for the group presentation is reminded/ discussed (e.g. no longer than 5 min.) and the overall time for all groups' presentations is discussed as well (32 min.).

3.3. Reflection (10 min.)

Questions for reflection:

1. What tasks did I perform while working on a project?
2. How (in what way) did learn/ work?
3. What did I manage to lean?
4. What did I do the best? Why?
5. Were there any difficulties? Why/
6. What could I do differently next time in order to improve the project/ cooperation?

Tips for the teacher

• Provide help based on the students' needs;
• Feedback is important for a quality process, and it is recommended that students would be asked to interact, discuss, display and so on. Active activities will encourage students' thinking (to make decisions, to argue, assess, etc.), to critically evaluate, to evaluate;
• Considering the interdisciplinary nature of the task, think and give students the opportunity to consult various specialists (design, media, economics, etc.).
• Trips to engineering companies, allowing students to actually see the implementation of engineering projects, get acquainted with the conditions of real work and engi-

Tip for the teacher

• If needed, you can discuss the design / originality of design; also assign students the task, for example, to find information and prepare presentations on original creative projects, discuss creative works made by other students, etc.

Tips for the teacher

• Discuss with students how you all will evaluate teamwork, according to which criteria teams will be assessed/ rewarded (for example, for the most points scored, for the best advertising, the original idea, and others);
• Notice positive things in each student's work and only then discuss how to improve their work activities.

LESSONS 9-12

STUDENT'S MISCONCEPTIONS

A teacher should try to observe the common difficulties during group work:

1. Students do not contribute to the "brainstorming" or other activities. Perhaps they have already decided what they would like to do, but they find it hard to see not only their own specific idea but also other ways to solve the problem. It is hard for the team to make the best decision on time. Help students address these emerging issues. Ask the students to talk about the positive and negative aspects of each idea. When students begin to compare their ideas, they should be able to talk more directly about engineering problems.
2. If student s' plans are not well prepared or described, this can mean disagreements in the team, or different concepts about what the group plan really is. Help students fill in questionnaires. Each member of the group should agree on a list of materials, ideas and a plan.
3. When the students completed the first product / project design / layout / project in order to identify and implement possible improvements, help students identify "weaknesses". Each improvement should address a particular problem, and if the improvement means something completely new, students should be able to reasonably justify their decision.
4. If the first idea / project has failed, give students the opportunity to make mistakes in their first design / layout / project, and then give them the opportunity to make another cycle of improvement so that students would become more aware of the application of the engineering creative process in the future.

LESSONS 9-12

TERMS AND USEFUL INFORMATION

Terraforming - a hypothetical change of climate and geological conditions of a planet surface, in order for the planet to become more similar to the Earth.

LESSONS 9-12

SOURCES

Sustainable urban farming ideas that think inside the box. Todd Woody [accessed on 2018 04 10]. Internet link: < https://grist.org/article/2010-04-05-agriculture-2-0/ >.

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BASED ON

Specializuoto ugdymo krypties programa (pradinio, pagrindinio ir vidurinio ugdymo kartu su inžineriniu ugdymu programų) inžinerinio ugdymo dalis, patvirtinta Lietuvos Respublikos švietimo ir mokslo ministro 2014 m. rugpjūčio 8 d. Internet link: <https://www.smm.lt/uploads/documents/svietimas/ugdymoprogramos/isakymas%20del%20inzinerines%20programos1.pdf >.

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