STEM LABYRINTH

Intellectual output 1

2021

Toolkit Promoting STEM Education Content

Co-funded by the Erasmus+ Programme of the European Union

Project: STEM Labyrinth as a method for increasing the level of knowledge through problem solving
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Activity 1.0

Description of the output

Partners responsible: all

Nowadays, the world has been changing rapidly, and the knowledge and skills acquired today are not foreseen to be sufficient while preparing our students for life. It is emphasized that the 21st century skills, such as digital skills, critical thinking, cooperation, problem solving, innovative and analytical thinking, are more than required. Technology has been improving so rapidly that it is of great significance for students to adapt to these constant changes in technology. Individual competencies in STEM subjects (science, technology, engineering and mathematics) are getting more important for the occupations of the future which are based on high technology. Therefore, innovative approaches are required in education.

As teachers, we need to be aware of the changes and the needs of the today's students. We have noticed that these generations of students have low-attention disorders, just because they are born with the technology. They are used to get to the information in just one click on their phones, tablets, and computers, so being in the classroom, being taught in a traditional way, by old textbooks, shows that the educational system is not efficient. According to the learning patterns and students' needs, this project intends to develop interactive materials that will help students to develop problem-solving skills. Their capacity to understand problems situated in novel and cross-curricular settings will be encouraged; they will learn to identify relevant information or constraints; to represent possible alternatives or solution paths, to develop solution strategies, and to solve problems and communicate the solutions.

Firstly, the project is aimed to develop the so called "STEM skills" in students (Science, Technology, Engineering and Math), which can be considered basic skills and are, for this, the main focus of our project. Moreover, they are considered as very challenging and not attractive to students, which is shown in the latest PISA tests. All the project's partner schools have identified a need to improve the quality of education in science, mathematics and technology, and have submitted a project aimed at developing a joint framework to support the involvement of pupils in learning.

As one of the most important horizontal priorities, we emphasize Innovative practices in a digital era according to the objectives of our project. In this strategic partnership, we promote innovative methods and pedagogies in the direction of increasing the motivation of students. Smartphone app for schools and Toolkit materials for promoting STEM will give innovative practices in schools for non-formal learning on real-life problems, supporting ICT-based teaching; supporting teachers in acquiring or improving the use of ICT for learning; promoting OER as priorities.

Toolkit promoting STEM Education, as IO-1, provides core messages, materials, and communications strategies to help schools and policy makers overcome such challenges and build strong support for STEM education initiatives. This Toolkit contains a range of implementation tools, from conducted analysis on STEM education policies and STEM teachers' practices in partner countries, finding partners strategies to support for carrying out a needs assessment when developing own STEM program. There is also implementation advice on how to choose a curriculum, design and adapt interactive lesson plans – including already prepared ones with this proposal. Designed to be free and friendly this Toolkit is accessible to all students, teachers, and educational community.

Participants

The activities related to Intellectual output 1 – "Toolkit promoting STEM Education" are about gathering information and doing research in the different European countries, so we the work was allocated to every partner organization to be performed by 2-3 teachers/professionals. In this IO there were also working days for technicians for creation and updating the e-Toolkit.

The partners and participants in the delivery of this output are the following organizations:

1. ATLME Association of European Movements, Portugal
2. AMETA Association of European Education and Mobility, North Macedonia
3. Learnmera Oy, Finland
4. DOUKA EKPAIDEFTIRIA AE, Greece
5. Martna Pohikool school, Estonia
6. Enjoy Italy by Alessandro Gariano, Italy
7. Agios Georgios Lyceum, Cyprus

Implementation and Content

The deliverables of the output were produced in the period between 01.12.2020 and 30.03.2021. All the partners have been allocated tasks and responsibilities to create and develop separate activities to be combined in an interactive pdf Toolkit. This toolkit contains two parts, described as follows.

Activity 1.1

Questionnaire results of the STEM education policies and practices

Partners responsible: All

Studies funded by the European Commission or conducted by (STEM) communities such as the STEM Alliance have highlighted major issues regarding the situation of STEM in European education systems: the low attractiveness of STEM studies and careers, or the unmet labour-market needs in STEM-related sectors that are expected to grow in the future. To address these problems, many initiatives and programmes have been pursued. In this context, our partnership, joined forces to conduct an analysis on STEM education policies and STEM teachers' practices in partner countries.

Within the partnership, we administered questionnaires to teachers, educators, administrators, and policy makers to get informed of the level of implementation of STEM activities in each of the partner countries' education systems.

We received more than 140 responses to the questions contained in the questionnaire.

The questions and the responses respectively are presented in the tables below, per country:

1. Has STEM education been introduced in your country? (%)

	Yes, as a part of the National Education Policy and incorporated in the curriculum	Yes, as part of extracurricular activities and project activities	Yes, part of the non-formal education (programs, courses or certification)	No
Portugal	28.6	48.6	14.3	8.6
Republic of North Macedonia	0	34.8	60.9	4.4
Finland	22.2	44.4	22.2	11.1
Greece	7.1	57.1	35.7	0
Estonia	30	60	10	0
Italy	6,3	75	6,3	12,5
Cyprus	0	60	25	15

2. What model of STEM education has been introduced in your school, region, and country? (%)

	Disciplinary STEM (Science, Technology, Engineering, Math)	Integrated STEM focusing on combining two or more disciplines to produce critical thinking, real world application, and creative problem solving	The Disciplinary and Integrated STEM model that acknowledges both to summarize programs at the national policy level	The model with no definition of STEM education	Adding additional science and mathematics into existing disciplines	Other
Portugal	17.1	25.7	11.4	20	8.6	11.4
Republic of N. Macedonia	0	26.1	0.1	30.4	39.1	4.3
Finland	11.1	22.2	0	56.6	11.1	11.1
Greece	35.7	35.7	0	21.4	7.1	0
Estonia	25	40	5	15	15	0
Italy	12,5	12,5	25	31,3	6,3	12,6
Cyprus	0	45	0	40	10	5

3. Are business and industry partners involved with STEM education in your country or school? (%)

	Yes	No	I don't know
Portugal	34.3	22.9	42.9
Republic of North Macedonia	13	26.1	60.9
Finland	66.7	11.1	22.2
Greece	50	35.7	14.3
Estonia	55	0	45
Italy	43	31,3	25
Cyprus	15	70	15

4. Is there more time for teaching math and science at your school as a result of STEM? (%)

	Yes	No	Other
Portugal	11.4	85.7	2.9
Republic of North Macedonia	39.1	43.5	17.4
Finland	55.6	44.4	0
Greece	57.1	35.7	7.1
Estonia	25	60	15
Italy	18,8	75	6,3
Cyprus	5	70	25

5. Is there a specialized STEM lab in your school? (%)

	Yes	No	Other
Portugal	22.9	77.1	0
Republic of North Macedonia	13	87	0
Finland	66.7	33.3	0
Greece	42.9	57.1	0
Estonia	25	75	0
Italy	50	50	0
Cyprus	0	100	0

6. Do you have teachers in your country or school who are certified in STEM? (%)

	Yes	No	I don't know	Other
Portugal	42.9	31.4	17.1	2.9
Republic of North Macedonia	30.4	47.8	21.8	0
Finland	44.4	22.2	22.2	11.1
Greece	57.1	42.9	0	0
Estonia	30		10	0
Italy	18,8	56,3	18,8	6,3
Cyprus	10	75	15	0

7. Are professional development opportunities for STEM regularly provided to teachers in your country or school? (%)

	Yes	No	Other
Portugal	34.3	54.3	5.7
Republic of North Macedonia	0	100	0
Finland	55.5	44.5	0
Greece	42.9	50	7.1
Estonia	55	25	20
Italy	31,5	56,3	12,6
Cyprus	0	95	5

8. Are STEM students regularly challenged by complex problems related to real world scenarios? (%)

	Not at all	Slightly	Moderately	A lot
Portugal	0	40	57.1	2.9
Republic of North Macedonia	8.7	26.1	26.1	39.1
Finland	0	44.4	33.3	22.2
Greece	0	14.3	42.9	42.9
Estonia	1	2	16	1
Italy	18,8	56,3	25	0

9. Do you have measures of student achievement in STEM subjects that are integrated? (%)

	Yes	No	Other
Portugal	28.6	71.4	0
Republic of North Macedonia	17.4	78.3	4.3
Finland	44.4	33.3	22.2
Greece	21.4	78.6	0
Estonia	70	20	10
Italy	43,8	50	6,3
Cyprus	10	75	15

10. What pedagogical approaches are you using in your STEM teaching?

	Traditional direct instruction	Teaching with experiments	Project-/Problem-based approach	Inquiry-Based Science Education	Collaborative and peer learning	Flipped classroom	Integrated learning	Differentiated learning
Portugal	37.1	74.3	60	20	57.1	22.9	5.7	20
Republic of NthMac	43.5	43.5	65.2	43.5	13	17.4	65.2	13
Finland	55.6	55.6	88.9	33.3	44.4	33.3	56.6	0
Greece	21.4	42.9	78.6	42.9	57.1	28.6	21.4	14.3
Estonia	65	65	85	50		40	75	15
Italy	75	50	43,8	12,5	87,5	37,5	6,3	0
Cyprus	0	70	40	0	25	10	0	75

11. Which learning resources / materials are you currently using when STEM teaching? (%)

	Paper-based materials	Audio/video materials	Robots	STEM Mobile apps	Web-based or computer-based simulations	STEM-specific software (e.g. Geogebra, Function Plotter…)	Word processors, Presentations, Data sets / Spreadsheets	Online collaborative tools (Padlet, Mentimeter, Kahoot…)	Resources published by private companies operating in STEM fields
Portugal	62.9	80	17.1	31.4	48.6	34.3	48.6	62.9	2.9
Republic of North Macedonia	52.2	91.3	13	13	56.5	30.4	52.2	34.8	0
Finland	55.6	66.7	22.2	22.2	22.2	66.7	88.9	44.4	22.2
Greece	28.6	57.1	28.6	14.3	50	21.4	35.7	57.7	35.7
Estonia	55	85	85	40	55	50	45	85	15
Italy	75	81,3	25	12,5	37,5	6,3	43,8	43,8	6,3
Cyprus	10	50	0	15	5	75	65	5	10

12. How do you usually learn about the teaching resources you are using in class?

	They are shared by the educational authorities in my country	They are shared by my network of peers	I actively search the Web for relevant teaching resources	I subscribe to the information channels of national and international STEM education projects, which are publicly funded (social media, newsletters...)	Other
Portugal	34.3	54.3	74.3	28.6	0
Republic of North Macedonia	18.2	31.8	90.9	45.5	0
Finland	11.1	55.6	77.8	11.1	11.1
Greece	14.3	50	100	21.4	0
Estonia	60	65	80	40	20
Italy	31,3	43,8	62,5	25	6,3
Cyprus	25	95	25	0	0

13. Which learning resources / materials would you like to use, but do not have at your disposal? (%)

	Smartphone STEM apps	Robots	Graphing calculators	Experimental lab	Web-based or computer-based simulations	Augmented reality/ Virtual reality tools (Virtual Labs)	Other
Portugal	31.4	31.4	11.4	40	22.9	51.4	0
Republic of North Macedonia	65.2	43.5	21.7	60.9	47.8	52.2	4.3
Finland	33.3	55.6	0	77.8	33.3	66.7	11.1
Greece	35.7	50	14.3	50	42.9	64.3	0
Estonia	50	60	50	80	70	75	5
Italy	31,3	25	18,8	56,3	18,8	62,5	0
Cyprus	70	20	0	80	15	55	0

14. You would like to see more support for schools from private companies operating in STEM fields in:

	Facilitating company visits	Having STEM	Offering teacher and student placements	Making teaching resources available to schools	Allowing access to hardware and equipment	Other financial support
Portugal	62.9	54.3	45.7	74.3	45.7	14.3
Republic of North Macedonia	34.8	43.5	52.5	60.9	79.6	39.1
Finland	55.6	77.8	33.3	66.7	33.3	33.3
Greece	42.9	85.7	42.9	50	64.3	28.6
Estonia	85	75	65	80	50	35
Italy	62,5	50	43,8	50	43,8	50
Cyprus	45	40	30	35	50	70

15. Do you receive the support of the following groups to improve your STEM teaching? (%)

	Other teacher(s) of the same subject	Other teacher(s) of a different STEM subject	School STEM administrator	School ICT / technology coordinator	Experts from outside the school (universities, industry, private	An online helpdesk, community or website	Other
Portugal	77.1	34.3	8.6	37.1	20	20	2.9
Republic of North Macedonia	34.8	34.8	4.3	17.4	26.1	47.8	13
Finland	88.9	66.7	11.1	33.3	22.2	44.4	11.1
Greece	57.1	35.7	21.4	42.9	35.7	28.6	7.1
Estonia	40	50	20	65	45	60	0
Italy	50	50	0	56,3	50	31,3	0
Cyprus	90	75	0	0	25	0	0

16. Do your colleagues and head of school share a positive vision about innovative STEM teaching at your school? Examples of innovative STEM teaching include: Inquiry-Based Science Education,

	Yes	No
Portugal	85.7	14.3
Republic of North Macedonia	73.9	26.1
Finland	100	0
Greece	85.7	14.3
Estonia	35	65
Italy	81,3	18,8
Cyprus	70	30

17. In your opinion, does innovative STEM teaching (using ICT, and innovative pedagogical approaches) have a positive impact on the following? (%)

	Students are more motivated for learning	Students feel more autonomous in their learning	Students understand more easily what they learn	Students develop their critical thinking	Students develop their problem solving skills	Students become more interested in STEM careers	ICT improves the class climate (students are more engaged, less disturbing)	Other
Portugal	82.9	51.4	37.1	65.7	65.7	31.4	31.4	2.9
Republic of North Macedonia	60.9	21.7	43.5	69.6	69.6	47.8	30.4	0
Finland	88.9	55.6	55.6	55.6	77.8	66.7	55.6	0
Greece	85.7	64.3	64.3	85.7	92.9	42.9	21.4	0
Estonia	75	75	65	75	85	40	60	5
Italy	87,5	50	56,3	56,3	68,8	31,3	56,3	0
Cyprus	45	85	60	95	45	45	30	0

18. What is your professional role? (%)

	Educator	Administrator	Part of industry, private company	Education policy maker	Other
Portugal	100	0	0	0	0
Republic of North Macedonia	73.9	0	26.1	0	0
Finland	77.8	0	11.1	0	11.1
Greece	78.6	14.3	0	0	7.1
Estonia	80	5	10	0	5
Italy	87,5	0	0	6,3	6,3
Cyprus	85	0	15	0	0

19. Level of education you are involved in: (%)

	Elementary	Middle School	High School	Institution of Higher Learning	Other
Portugal	5.7	57.1	54.3	17.1	2.9
Republic of North Macedonia	8.7	34.8	26.1	17.3	13.1
Finland	11.1	11.1	88.9	0	0
Greece	28.6	21.4	42.9	21.4	14.2
Estonia	40	65	25	10	20
Italy	18,8	25	62,5	0	0
Cyprus	0	20	65	5	10

Activity 1.2

Analysis of the results on the STEM policies questionnaire

Partners responsible:
AMETA – Association for European education and mobility

The questionnaire results provided some crucial information and it serves as a starting point when it comes to the implementation of the project. What is essential is the fact that STEM, as an approach in teaching, have been introduced as part of the national curricula with very small percentage in most countries of the partnership (Portugal, Estonia, and Finland). At the same time, it has not been announced, or even less encouraged in countries like North Macedonia, Cyprus, Italy, and Greece.

However, the educators in the fore mentioned countries are aware of the advantages of the STEM concept and they have been using it as part of their extracurricular, project activities, and as part of their non-formal educational courses, programs, etc. offered to students. The model of STEM education being used is mostly focused on combining two or more disciplines to encourage critical thinking, real world application, and problem solving techniques and skills among students. Less used is the approach with no definition of STEM education, in which teachers and educators search for activities and resources to be implemented within the lessons, to teach their students the much-needed competences in the 21 st century.

Moreover, there are only two countries with a very small percentage of answers related to the support from the business and industry partners in the STEM education. This is a positive fact that shows the importanceof involvement of relevant stakeholders in the process of education, especially when it comes to STEM education. This interdisciplinary approach requires, largely, practical application of the knowledge and skills learnt, and it can only be achieved with the support of the business and industry sector.

Besides the disadvantages in some countries related to the national curriculum containing instructions for STEM teaching, the schools also face difficulties when it comes to implementation of STEM lessons in specialized laboratories. Only in Finland and Italy the schools are equipped with additional classrooms and laboratories specialized for STEM activities, and supplied with resources. For these activities to be realized, the teachers take initiatives to educate themselves through participation in projects, structured courses, informal trainings, and other workshops. They learn about the new trends in STEM and opportunities for professional development through colleagues, newsletters, journals, and online resources, due to the lack of support by the authorities. As a result to this, the questionnaire shows that mostly in Finland, Greece, and Estonia, the teachers are provided with regular opportunities for professional development in STEM. On the other hand, North Macedonia and Cyprus are the countries whose teachers receive no opportunities from the relevant state institutions. Consequently, this development leads

to a larger number of certified teachers in STEM in Greece, Finland, and Portugal, and less in North Macedonia, Estonia, Italy, and Cyprus. However, we can conclude that in each country the number of teachers certified in STEM is increasing, even though very few opportunities are provided, due to the teachers' motivation and desire for professional upgrade.

When it comes to the teaching and pedagogical approaches used in the STEM lessons, each country presented, more or less, the same results. Namely, the approaches used within the educational activities include, by the extent of use, problem and project based approach, teaching with experiments, inquiry-based learning, collaborative and peer learning, and the traditional direct instruction. Less used are the integrated learning, flipped classroom method, and differentiated learning. Perhaps, the reason for the high level of use of the traditional teaching methods, and the low percentage of use of the new teaching approaches reflects the age of the educators and their willingness to change and adapt to the new trends in teaching.

The STEM approach requires various teaching materials and resources, and their use depends on the support provided by the Ministries and the schools. The countries, which have advanced related to STEM, use more sophisticated and expensive resources as robots, STEM mobile apps, and web-based simulations. The teachers from the other countries, which receive less or no support, manage to be competent in the field, by searching free online materials and software, and other collaborative tools, like Padlet, Mentimeter, Kahoot, and other. Except the Estonian schools, who are informed about the resources they can use by their relevant institutions, the teachers in all other countries of the partnership learn about the trends and novelties in this field by their peers, or they actively search the internet to find relevant materials, or they subscribe to information channels, mostly funded

STEM projects.

Regarding the outcomes in the students' motivation and development of key competences, the results in each country show that the innovative STEM teaching has positive impact over their motivation and autonomous learning, they develop skills for

critical thinking and problem solving, they understand what they learn better, and eventually become more interested in STEM careers. At the same time, the results vary related to the time spent teaching math and science with STEM. In some countries, the answers show that teachers can integrate these disciplines (Finland and Greece), while in the others, there is less time for integration of them.

What is also very important to be noted is the fact that only the teachers is Estonia have established measures and criteria to assess the students' achievement in the integrated STEM subjects. Otherwise, all the teachers in all countries share the positive opinion and vision about the STEM teaching, and the innovative approaches like the inquiry-based science education, project-based learning, flipped classroom, etc.

For the purpose of quality teaching and implementing STEM, the teachers need specialized experiment laboratories, robots, augmented reality or virtual reality tools,as stated in the questionnaire. Most of these resources are available online and free, however, the teachers need to be informed about them regularly, and at the same time educated on how to use them in their classrooms. In addition, the teachers' opinion, in all the countries where the questionnaire was administered, shows willingness and desire for bigger involvement of the private companies operating in STEM fields, especially in facilitating company visits, on-site or online professional presentations, offering teacher and student placements, allowing access to hardware and equipment. The percentage for the need of financial support differs from country to country, where Portugal, Estonia, and Greece need less, and Italy and Cyprus needing it most. The reason why we take the results of the questionnaires as relevant is the fact that more than 90% of the participants in the survey are teachers and educators, mostly coming from secondary schools in the countries of the partnership. As the target group of the project are 14 – 18 year old students, we have an insight of the needs of the teachers' opinions, their opportunities for professional development and the resources they have at their disposal.

Activity 1.3

STEM community map

Partners responsible: All

Database of STEM community (communication strategies for finding partners and supporters)

A high-functioning STEM community is youth-focused, action-oriented, hands always on, adult-coached, and try-fail-try-again based. It is a means for a STEM community to not only transfer relevant knowledge, best practices, successful practicalities, and expected social norms but also to share, embed, and make easily accessible those best practices and lessons learned within the generations of STEM stakeholders in your community.

The building and development of a high-functioning STEM community is time-intensive, challenging, and dedication demanding.

The main goals of the STEM community are: building relationships, sharing resources, and opening opportunities. STEM Communities promote adult-child engagement in explorations, interactions, and conversations that are learner-centered, open-ended, and hands-on and cover a wide variety of topics. They:

- Bring together early childhood programs, schools, community centers, libraries, and museums to improve the quality of teaching and learning in early STEM
- Establish strong partnerships with families to ensure culturally relevant STEM materials and activities
- Provide professional learning support and resources to educators to reach out to families and support quality STEM teaching and learning across settings where children live and learn
- Foster positive attitudes toward STEM so that every child sees themselves as a STEM learner

Why is building a STEM community so important?

When families, teachers, and community members have a shared vision and work together to support children's STEM dispositions, interests, and competencies, everyone benefits. Families are empowered through engagement within formal and informal learning environments, which in turn empowers them to be their children's STEM advocates. This work is important because:

- Children's experiences in the early years lay the foundation for all later learning. Research shows a strong positive relationship between high-quality STEM experiences in children's early years and their later academic and literacy achievement in school.
- Social relationships and nurturing interactions with trusted adults are key to brain development and learning.
- Families play a critical role in promoting their children's development and learning.
- Business, industry, and other STEM workforce leaders provide powerful STEM role models for children and adults. This is especially true when these partners reflect children's and families' ethnicities and languages, include women as well as men, and work in a variety of STEM jobs and careers in the local community.

The partners in the consortium have implemented the survey as a part of an analysis for creation of a STEM community map (communication strategies for finding partners and supporters and creation of a database with the STEM community) within the project STEM Labyrinth.
The Survey was addressed to Schools, Universities, STEM associations, Business society, Higher education community, State boards of education and education agencies, Museums, NGOs etc., which have good practices related to STEM education.
The STEM community map is not designed only to transfer relevant knowledge, best practices, successful practicalities, and expected social norms but also to share, embed, and make easily accessible those best practices and lessons learned within the generations of STEM stakeholders in your community.

Portugal

Agrupamento de Escola de Alcanena
Website: http://ae.alcanena.ccems.pt/

The Alcanena Schools group is the first in Europe to receive the STEM School Label Proficiency Level Seal. This recognition aims to support schools in the development of STEM Projects (Science, Tecnology, Engineering and Mathematics, or Science, Technology, Engineering and Mathematics, in Portuguese), to recognize good practices and to promote the creation of networks between the different partners of research institutions. teaching. According to the official website of the European initiative, a STEM school is defined by having a clear STEM strategy, which contains different criteria and key elements. In the process of identifying these schools, an online tool is filled in that simultaneously points out areas for improvement. There are 3 levels of STEM certifications, depending on the strategy being reduced - Competent, Advanced - Proficient and exceptional - Expert.
On this scale, the Alcanena School Group achieved the second level distinction (Proficient) and five other Portuguese schools were awarded the Label Competent: the Cidade do Entroncamento School Group, the Loulé Secondary School, the Oliveira do Professional School Tábua e Arganil Hospital, Odemira Secondary School and Almada Professional School. Of the certified educational institutions, Entroncamento, Alcanena and Loulé were also selected to be STEM School Ambassadors, out of only 20 schools at European level. The STEM Ambassador Schools will have the opportunity to collaborate with others from all over Europe during this school year, as was the example of the 33rd Science Projects Workshop, organized by STEM School Label and Scientix, which took place on the 20th and 21st of September 2019 in Brussels.
STEM School Label is a project launched in 2017, a joint initiative of European Schoolnet, Ciência Viva (Portugal), Maioson pour la Science d'Alsace (France), the Science Promotion Center of Serbia and the Center for Lithuanian Education Development, and is supported by the Erasmus + program.

Fábrica Centro Ciência Viva de Aveiro
Website: https://www.ua.pt/pt/fabrica/page/23546

Ciência Viva has established over the years a partnership with IBM Portugal in the development of activities for students and teacher training in the scope of STEM (Science, Technology, Engineering and Mathematics), inspired by the resources available at www.teatcherstryscience. org.
In the academic year 2017/2018, Fábrica Centro Ciência Viva de Aveiro joined this project with a program of initiatives to promote the development of STEM and bring children and young people closer to Science and Technology.
As part of this project, a program was developed dedicated to teachers and students, in which participants were encouraged to develop group work, scientific rigor, the construction of teaching materials and small projects.

Direção Geral da Educação
Website: https://www.dge.mec.pt/sites/default/files/EPIPSE/top100_pt.pdf

The Directorate-General for Education (DGE) is a central service of the direct administration of the State with administrative autonomy. Its mission is to

ensure the implementation of policies related to the pedagogical and didactic component of pre-school education, basic and secondary education and out-of-school education, providing technical support to its formulation and monitoring and evaluating its implementation. It also coordinates the planning of the various tests and exams and designs, organizes and carries out risk prevention, safety and violence control measures in schools.

INOVLABS

Website: https://inovlabs.com/pt/

InovLabs is an educational startup that advises schools and teachers on implementing STEM education (Science, Technology, Engineering, Mathematics), providing an integrated ecosystem of products and services to teach STEM inside and outside the classroom.
We provide interdisciplinary projects for 2nd and 3rd cycles, tailored to fit the school curriculum, which can be directly implemented through our ready-to-go activities.

The program dedicated to teachers involved the realization of Workshops ** for **** teachers of the 1st Cycle of Basic Education, which took place at the Fábrica Centro Ciência Viva in Aveiro and at the José Estêvão Secondary School, involving ** 54 ** teachers in total 14 hours of training.
The program for students involved practical sessions with students from pre-school and 1st, 2nd, 3rd and 4th years of the 1st Cycle of Basic Education, which took place in the context of the classroom at the Cluster of Schools of Aveiro, in the Cluster of José Estêvão Schools, in the Mário Sacramento School Group, in the Gafanha da Nazaré School Group, in the Sever do Vouga School Group, and in the Oliveirinha School Group.
544 students were involved in the various activities: 219 in experiments with magnets, 170 in experiments with electricity and 155 in the construction of a terrarium.

WORKSHOPS FOR TEACHERS IN THE 1st CYCLE OF BASIC EDUCATION
1. Workshop "Experiences with magnets"
2. Workshop "Experiences with electricity"
3. Workshop "Experiences with light"
ACTIVITIES FOR STUDENTS
1. Experiments with magnets
2. Experiences with electricity
3. Construction of a terrarium
a joint initiative of European Schoolnet, Ciência Viva (Portugal), Maioson pour la Science d'Alsace (France), the Science Promotion Center of Serbia and the Center for Lithuanian Education Development, and is supported by the Erasmus + program.

Agrupamento de Escolas de Barcelos

Website: www.aebarcelos.pt

Róbótic
Robotics Club
Robotics is a technological educational branch that encompasses computers, robots and computing, which deals with systems composed of automatic mechanical parts and controlled by integrated circuits, making mechanical systems motorized, controlled manually or automatically by electrical circuits.
The Robotics Club aims to promote robotics and

also provide school students with an interesting and fun extracurricular event, where they apply in practice the knowledge acquired during classes.
We participated in several European meetings, and with fantastic results

IPCA

Website: https://est.ipca.pt/

The Escola Superior de Tecnologia (EST) started its activity in October 2004 and currently has an educational offer focused on Engineering, offering undergraduate, master's and professional technicians courses in the fields of computer science, digital games, computer graphics , electronics, automation, robotics, networks, machining and automotive mechanics.
In recent years, EST has been investing in the area of digital entertainment as one of the main opportunities of economic and academic potential, both in Europe and in the world. As a result of this commitment, in 2010, the first Digital Engineering Development Degree course in the country was created, as well as the construction of the first Portuguese Research Center entirely dedicated to digital games, the "Digital Games Lab".
EST is, therefore, headquartered at the IPCA Campus, in Barcelos, with a total area of over two thousand square meters, equipped at the highest level, promoting teaching applied to practice and encouraging students to develop and get involved in projects innovative research and development using available laboratories and equipment. Result of this work are the prizes won by EST students in several competitions, national and international.
With the entry into service of the Higher Professional Technical Courses (TeSP), EST expanded its educational offer to the cities of Braga (in 2014) and Guimarães (in 2015). These new courses also made it possible to invest in other areas, namely technical design, machining and car mechanics.
In parallel to the teaching activity, EST has organized events to publicize the school, namely iDroneCup, which this year becomes Idrone Experience, JobShop, Open EST, among others, aimed at its students and the surrounding educational community.
The dissemination of projects developed by students and teachers is also done through meetings of the Advisory Committee, an event that annually brings together the largest companies in the sectors in which EST operates.
The EST management salutes its entire academic community, with a special greeting to its teachers, students and graduates, who, with their spirit of sacrifice and ambition, contribute daily to the name and success of this School.

Sociedade Portuguesa de Robótica

Website: http://www.sprobotica.pt/

The Portuguese Robotics Society was founded in April 2006. The membership is open to individuals and institutions (academy and industry). Our main goals are to foster education, scientific research, technological development and applications (industry and services) of robotic systems. Our annual event is the Portuguese Robotics Open, including robot competitions for university and high school levels, as well as a technical conference which has been co-sponsored by IEEE in last few years.

Republic of North Macedonia

Young Engineers Skopje

Website: https://skopje.youngengineers.mk/en/home-3/

Young Engineers curriculum is based on the most crucial skills students need to prosper in our current world. Skills include high-order thinking, critical and creative thinking, acquiring information systems and media literacy, developing individual and social responsibilities and lifelong learning.

The Young Engineers programs are based on the "spiral education method", in which the student is introduced to complex terms and information from a different perspective at different levels. Our pedagogical level of programs and the methods we use are alwaysupdated in order to give our students the tools they need to succeed now and in the future.

e² Young Engineers programs include after-school enrichment classes, pre-school classes, summer camps, birthday parties and special events where children are given an opportunity to LEARN while having FUN building with the world's favorite building block – LEGO®.

Our programs utilize an EDUTAINMENT (education + entertainment) approach, transforming the learning process into a game while introducing children to theoretical knowledge and practical implementation. Each session provides theoretical knowledge and practical implementation in Science, Technology, Engineering and Mathematics (STEM) through the use of LEGO® bricks. Our unique method incorporates stories, experiments and demonstrations that are specially designed to deliver a multi-sensory experience. In this way, the learning experience is enhanced and made more memorable.

Our students indicate improved achievements in school when participating in our programs, because e² Young Engineers programs stands for and contribute to:

- Statistically tested and proven as efficient,
- We make children love STEM,
- Fun and innovative,
- Encourage independent and creative thinking,
- Develop High-Order thinking skills,
- Develop the ability to analyze engineering processes,
- Acquire engineering implementation skills,
- Develop problem solving skills,
- Develop teamwork capabilities,
- Develop self-confidence and a sense of self-efficacy,
- Develop computer orientation.

STEM Academy

Website: http://stem-academy.org/

Educational organization that aims to develop the STEM competences in young students, 5 to 16 years old. STEM Academy uses the methodology that has been developed by LEGO® Education for more than 3 decades. Characteristic of these programs is that they provide lifelong education. The essence of the methodology is that children must be guided by professional educators and constantly supported to become systematically creative: combining logic and creative thinking through play and imagination, giving them guidance that will help them form their way of thinking, combining, exploring and transforming ideas and objects.

Faculty of Natural Sciences and Mathematics, Skopje

Website: www.pmf.ukim.edu.mk

Ever since its foundation in 1946, the Faculty of Natural Sciences and Mathematics has been involved in solving practical problems that concern society. The base ground that was inherited from the previous activities was used to enlarge and widen the areas of scientific interest. Today the faculty consists of six institutes: mathematics, physics, chemistry, biology, geography and ethnology and anthropology. In accordance with the scientific interest, the staff is organized in divisions as follows: Institute of mathematics, Institute of physics, Institute of chemistry, Institute of biology, Institute of geography, Institute of ethnology and anthropology. The Faculty of Natural Sciences and Mathematics in Skopje is the only institution of its kind in the Republic of North Macedonia. About 11 000 students have graduated at this faculty. About 850 master thesis and 450 PhD thesis are defended.

The activities and experience of the Faculty of Natural Sciences and Mathematics can be divided into two main groups.

1. Science education

The Faculty staff has very big experience in working with teachers and students. From its very beginning the Faculty produces science teachers for secondary low (middle school) school and for secondary high school. Usually, the teachers for low secondary are educated and trained to teach two subjects: chemistry and biology or mathematics and physics. On the other hand, high secondary teachers are educated and trained only in one subject: mathematics, physics, chemistry, biology and geography. During the process of educating prospective teachers, the Faculty staff visits schools, works with teachers and students, prepares activities, performs science education research activities and many other activities concerning the science education. The Faculty staff regularly take activities in the frame of the Ministry of education and science, as well as of the Bureau for development of the education, creating curricula, textbooks, workbooks and other materials. This experience that was built for decades is priceless.

2. Science research

Within the Institute of physics, a group ofscientists work in the area of photovoltaics. Photovoltaics are used for direct conversion of light into electricity. The Institute is equipped with a laboratory for depositing layers of semiconductors and materials used in this field as well as with a laboratory for investigation of the characteristics of the cells. The scientists from this group have published many science articles in the major world scientific journals. The students can use these resources in order to produce solar cells and investigate their characteristics. Within the Institute of biology and Institute of physics there is a group of scientists that work in the field of ecology.

UGD Goce Delcev University

Website: https://www.ugd.edu.mk/index.php/

Goce Delchev University in Shtip is a state university, ranked in the second place in the rankings of state universities in the country. As a young and vibrant higher education institution that constantly monitors the interests of young people and the latest global economic, industrial and technological trends, we create remarkable opportunities for higher education. Diplomas at Goce Delchev University in Shtip issues are internationally recognized and are reliable proof for entering both domestic and international labor

markets. Goce Delchev University in Shtip integrates 13 faculties and is organized in three university campuses. The lectures are conducted in training facilities set up in 12 cities in Macedonia. 16,000 students have already identified the University Goce Delchev in Shtip as an excellent opportunity for their academic development. Since the establishment of the University one of its main goals, besides creating of young educated people that will be competitive on the labor market and the needs of the modern society, has been the strive to provide excellent conditions for research that will not only meet the needs of its own staff, but of the business community as well, which has more dynamic requirements, in terms of resources, technology, services and innovative solutions to improve quality of life, community development and environmental protection.

During the last few years Macedonia has been following the European trend for educated society in all segments of professional life. The level of knowledge and skills that the society demands from the academic professionals and the prospective employees has been changing as well. Professionals need to possess knowledge, creativity, as well as innovative skills in order to be able to meet the demands of the market. In order to meet these demands science and research are playing an increasingly important role and they are substituting the merely academic researches with a variety of researches focused on innovative, interdisciplinary knowledge oriented to solution of practical problems in their regions and wider, as well as to meet the need for lifelong education of the workforce.

Through its specialized applied research center and modern equipped laboratories, Goce Delcev University provides an enviable base for research both for academic purposes and for assistance to the public and private sectors in breaking new grounds and becoming more competitive not only on the domestic market but on the international one as well. The University nourishes and produces academic values that traditionally stand high on the general scale of social values. The positive academic values are based on the driving force that comes as a result of the research activities. The academic heritage, independence, autonomy and credibility are the fundamental elements that can raise new generations of intellectuals, outstanding professionals and individuals who will take the responsibility for the future of the society. Research work plays an important role in achieving this goal as it helps develop the personal qualities of each individual as a crucial element of the academic community.

Research work within the University is based on an individual approach to projects that reflects and maintains the minimum development of academic nuclei. Thus, the University is presented as a mosaic picture of numerous research sections. Goce Delcev University strongly supports these research nuclei because as they rapidly develop the particular scientific field, they rapidly promote the University in Europe and worldwide. This support is presented by special research funds which, through defined procedure, can be used by particular research nuclei as a financial support to their research activities.

In order to support young scientists, the University promotes and finances special development programs such as second and third cycle study programs. The University will continue to motivate students by regularly involving them in ongoing research projects within the research nuclei-departments, as well as by introducing special awards for best research or professional papers made by students.

Institution name: Center for Innovations and Digital Education

Website: https://dig-ed.org/

The Center for Innovations and Digital Education DIGED is a non-governmental-organization founded by teachers and educators. It has a close cooperation with Scientix, and organizes activities for pupils and students related to STEM. It also provides courses for teachers who are willing to upgrade their skills and competences in ICT, mostly. There are several STEM programs that are being offered in the form of course and competitions, with an aim to develop critical thinking and STEM competences

Institution name: STEM Robotika Kocani

Website: https://www.facebook.com/stemroboticskocani

The educational center offers certified programs that are being applied in the world of science and technology. It is meant for children at the age of 5 to 16 years old, to design robots imitating the real world machines. They are meant to develop the children's creativity and critical thinking through LEGO EDUCATION programs. It also offers MINDSTORM EV3, WEDO 2 and SIMPLE MACHINE LEGO courses.

Institution name: BrainObrain Macedonia

Website: www.brainobrain.com.mk

The Brainbrain program is an innovative international program for the development of intellectual and life skills and abilities in children aged 4 to 14 years. All our coaches have a university degree and have experience working with children.
The program has two main goals:
Complete brain development (using Abacus Mental Arithmetic and VAC methods)
Personality development (using NLP techniques)
What results are expected from the program?

- Improve memory and concentration
- Visualization and creativity
- Direction, speed and accuracy
- Excellent arithmetic skills
- Leadership, determination, self-awareness
- Developed photographic memory
- Development of multitasking capabilities

Institution name: Alliance of Engineers Associations

Website: http://engineer.org.mk/

Mission
Coordinating the development of all fields of engineering science and profession, engineering practice and technology, through the scope and joint action of all engineering staff, in order to be the bearer of the technological development of the country and beyond.
Vision
To encourage and motivate young people in the development of engineering to be a front in the global innovation competition in the world, improving the quality and way of life.

Institution name: SOU Jane Sandanski Strumica

Website: http://www.jsandanski-strumica.edu.mk

The natural sciences are deeply rooted in the history of our school, and this trend continues, with the growing interest of students to enroll in the Natural - Mathematical field. In addition to the fact that many students see their future in the IT sector, it also contributes to the engagement and commitment of teachers from these areas, who know how to recognize valuable students and

motivate them to develop their own talent. The following is an example of what STEM (Science, Technology, Engineering and Mathematics) education should look like, with a great deal of emphasis at European level.

Our school successfully implements the Erasmus + KA2 project: Probot (Learning programming with the help of a robot), which is implemented together with six other high schools from European countries (Poland, Italy, Slovenia, Lithuania, Greece and Northern Macedonia), and the coordinator is a faculty from Katowice, Poland. We worked on developing lessons that are new and innovative, and teachers of informatics, mathematics and physics can use them in teaching, using programming as a basic link between the lessons and the Lego Mindstorm EV3 robot, which we procured for the project.

As a result of the project, a base of new creative lessons is expected, for the needs of these three subjects, which should stimulate the interest of students in natural sciences, as well as the importance of programming as a link in contemporary education. The project is addressed to 2 groups: secondary school teachers and high school students. Main goal: to increase innovation and interdisciplinarity of education among secondary schools of partner countries by developing and disseminating educational materials for pupils and teachers on the use of robot programming for STEM education.

The official website of the project is https://probot.smcebi.edu.pl, and will be upgraded until the end of the project, in order to obtain educational resources free to use.

Institution name: SOU Gimnazija Koco Racin Veles

Website: https://www.gimkocoracin.edu.mk/

The school has participated in several Erasmus projects on various topics. Participation in such projects strengthens the skills of the teacher who deals with complex situations in the classroom, and adopts new methods and tools. The projects promote an interdisciplinary approach based on real-world problems and innovative approaches, so that students can be creative, motivated and learn how to use science, math and technology in real-life situations to be ready to face the challenges of this fast-paced world growing world. Participation in projects also promotes awareness of the EU's cultural heritage and values, structure, vision and strategies for the future.

Finland

Institution name: Tampere University of Technology

Website: https://www.tuni.fi/en

Tampere University is one of the most multidisciplinary universities in Finland. Almost all internationally recognised fields of study are represented at our university. Tampere University was created in January 2019 by the merger of the University of Tampere and Tampere University of Technology, which joined forces to create a new foundation-based university. At the new University, technology and social sciences have come together in a unique way. Our research groups and projects conduct multidisciplinary research across institutional boundaries.

The research undertaken at our Centres of Excellences (CoE) ranges from game culture studies to tumour genetics.

Institution name: Aalto University

Website: https://www.aalto.fi/en

Aalto University is a community of bold thinkers where science and art meet technology and business. We build a sustainable future by creating novel solutions to major global challenges. We value responsibility, courage, and collaboration.
By merging three leading Finnish universities in 2010, Aalto was founded to work as a societally embedded research university. In a short space of time, we have since become a forerunner in our key areas. We are renowned for our sense of community and culture of entrepreneurship and innovation.

Institution name: LUMA Centre Finland
Website: https://www.luma.fi/en

LUMA Centre Finland was established 8 November 2013 as the umbrella organization for LUMA Centres in Finnish universities and university campuses to strengthen and promote their collaboration on national and international level. LUMA Centre Finland shares the national concern over the level of competence in mathematics, science, and technology in general, and over the insufficient amount of professionals in these fields.
The aim of the LUMA Centre Finland is to inspire and motivate children and youth into mathematics, science and technology through the latest methods and activities of science and technology education. The aim is also to support the life-long learning of teachers working on levels of education from early childhood to universities, and strengthen the development of research-based teaching.

Institution name: Åbo Akademi
Website: https://www.abo.fi/en

Åbo Akademi University is the Swedish-language multidisciplinary academic university in Finland. We contribute to society through general learning, education and new scientific knowledge.

With campuses in Turku and Vaasa, Åbo Akademi University offers internationally renowned research and education. Through cross-border collaboration, we serve as the gateway to Finland for the Nordic countries.
Our activities are steered by the values of academic tradition in terms of the freedom of research and education as well as ethical responsibility. We endeavour to enhance diversity, inclusion, equality and sustainability.

Institution name: STEM School Finland
Website: https://www.stemschoolfinland.com

STEM School Finland is the largest school in Finland arranging science and technology education. We have over 40 locations throughout Finland. Our teacher team consists of over 30 teachers, scientists and engineers working with the Science, Robotics and Programming courses, lesson plans and contents.

Institution name: The University of Helsinki
Website: https://www.helsinki.fi/en

The University of Helsinki is Finland's largest and oldest academic institution. Since 1640, it has contributed to the establishment of a fair and equal society that is considered the best in the world according to a number of indicators. Today, this multidisciplinary academic community solves problems that concern all of us, also on the global scale. A community of 40,000 students and employees is diversely open, comprehensively quality conscious and joyfully serious. Internationalisation means many things for us. Together we create solutions that will shape the future of our planet and all of humanity.

Institution name: Satakunta University of Applied Sciences
Website: https://www.samk.fi/en

Vision: All SAMK students will be employed. SAMK provides experts and developers for the region and promotes internationality and entrepreneurship in Satakunta.
The economic and industrial structure of the region requires SAMK to be able to offer extensive education and research opportunities in the fields of health care and social services , business administration, and technology. SAMK profiles itself as an industrial higher education institution.
SAMK has the responsibility to produce customizable competence to meet the modern and versatile needs of working life in the region of Satakunta and the neighbouring areas, and in the chosen fields all over Finland.

Institution name: University of Turku
Website: https://www.utu.fi/en

The University of Turku, located in Turku in southwestern Finland, is the third largest university in the country as measured by student enrollment, after the University of Helsinki and Tampere University. It was established in 1920 and also has facilities at Rauma, Pori, Kevo and Salo. The university is a member of the Coimbra Group.
The University's multidisciplinary strengths in research are biofuture; digital futures; cultural memory and social change; children, young people and learning; drug development and diagnostics; and sea and maritime studies.
The University of Turku has been involved in many research projects in the Peruvian Amazon. With the Peruvian Amazon Research Institute (Instituto de Investigaciones de la Amazonía Peruana – IIAP), based in Iquitos, has been studying the Amazon in the BIODAMAZ Project.

Estonia

Institution name: Robokaru Robootikakool
Website: www.robokaru.ee

Privately held school for after school activities. We use mainly LEGO robotics kits (WeDO, Spike, and Ev3). Students are ages between 6-16. We want to develop and implement robotics and programming to be available to all students in public schools. We use LEGO robots as problem solving tools and a large part of our curriculum is connected with First Lego League.
The aim of the activities of the hobby school is to create opportunities forchildren and young people for the versatile development of the personality and to support their development into a well-coped member of society through robotics training.
The task of the hobby school is to develop the creative abilities and engineering thinking of children and young people and to create opportunities for versatile leisure activities.

Institution name: MTÜ (NGO) Nuti-Võlur
Website: https://nutivolur.ee/
Short description:
MTÜ Nuti-Võlur operates in Võru County. We mainly conduct robotics and science hobby groups in Võru and several schools in Võru county. We work as the organizers of Võru Counties Robotics Day. We also conduct robotics camps in the summer and science mornings during school holidays. In addition, we organize training for instructors and teachers of general education schools. We are also the introducers of Six Bricks, Playbox and Novel Engineering methodologies in Estonia. In addition we conduct computer based schooling for adults.

We are interested in cooperation projects in the STEAM field that are aimed at kids aged 5-16. Triinu Grossmann (robotics teacher), Jaana Kõvatu (Six Bricks, Playbox, adults trainer). Contact address nutivolur@gmail.com

Institution name: TLÜ EDUSPACE uurimislabor (research laboratory)
Website: https://eduspace.tlu.ee/

EDUSPACE is a research laboratory for learning and teaching supported by technology. All scientists, faculty, students and teachers are welcome here to research, study or teach. The laboratory is equipped with modern research and educational technology equipment.
EDUSPACE's keywords are educational innovation and cooperation between Tallinn University, educational institutions and companies.
Our latest project is STEAM K12 PROJECT aim of which is to provide students of teacher training with the ability to use different STEAM approaches: robotics, sensors, virtual and augmented reality, electronics, statistics to enrich the subject with technology. Students learn to use tools to apply modern learning methods and to influence learning outcomes. As a result of the creation of the STEAM K12 digital learning material collection, students of teacher training will be given the skills and courage to use different STEAM approaches: robotics, sensors, virtual and augmented reality, electronics, statistics to enrich the subject with technology. Students learn to use tools to apply modern learning methods and to influence learning outcomes.
Read more https://e-koolikott.ee/kogumik/28660-STEAM-K12

Institution name: Insplay | Rekato Ltd
Website: https://www.insplay.eu/
Short description:

Our team is experienced in robotics and technology. Insplay's mission is to support the development of future talent and thus the emergence of a new wave of innovation in Estonia. In the field of robotics, we are the largest player in the Baltics, supplying thousands of educational robots to the Estonian market every year and supporting their use as a developmental learning tool.
We place emphasis on the development of the field of education through the organization of training, workshops and competitions.
Insplay offers a range of paid training and free counseling for the introduction of electronic and robotic devices in the range of educational products, especially for employees of educational institutions and instructors of hobby groups. At the training, we introduce the possibilities of using the products and give practical recommendations based on the national curriculum. We offer various solutions for using our products in natural sciences, technology studies, art and mathematics and other subjects. The training includes both a theoretical part and hands-on practical activities.
We have held special competitions for younger students at Robotex, the largest robotics competition in the Baltics
We have created a program ROBOMENTOR to support teachers in innovation progress. The Robomentor program aims to support creative and innovative teachers and robotics enthusiasts in disseminating good practice and mentoring experience. It is through active sharing and involvement that we encourage the use of other educational robots.
Also we have created several teaching materials on how to integrate STEM into formal education.

Institution name: HK Unicorn Squad
Website: https://unicornsquad.ee/

HK Unicorn Squad is a movement that offers technology education as a hobby education only for girls. The enterprise started in the autumn of 2018 with the aim of arousing and growing technical interest among girls through practical tasks. Our vision is to increase interest in technology, robotics and science among 7-14 year old girls.

HK Unicorn Squad aims to find out why there are few girls, why they are left out and how they can motivate girls to be more interested in technology. We have put forward two hypotheses, which we hope to answer with our actions:
Technology is an area for boys. Girls are not interested in technology and robotics circles.
Girl-only circles give a different effect compared to mixed groups.
It is a nationwide enterprise, and since the autumn of 2020, there are already 650 girls interested in.
It teaches physics, electronics and even drones.
The course starts with the simplest things. For example, learning an electrical topic starts with replacing a light bulb. In the end, however, the girls know how to water and assemble complex electrical circuits.

Greece

Institution name: Master of Science in Science, Technology, Engineering and Mathematics in Education (School of Pedagogical & Technological Education (ASPETE), Department of Education)
Website: http://stem.masters.aspete.gr/index.php/en/

Msc program aims to address the challenge of forging deeper learning in STEM by integrating design thinking as an approach to teaching in which students construct and demonstrate understanding through a form of design. The project builds on the notion of embracing Design objectives, essentially utilising and blending multimodal STEM-based learning and to introduce STEM students the design process and the creative process, as well as the nature of design thinking.
It is expected thatthis fusion between STEM and design will mitigate shortages and_skills mismatches in STEM. On the other hand the Msc aims to include model based computational models in STEM Education and to introduce STEM Msc students the concept of using models as the fundamental instructional unit in their inquiry based teaching and learning scenario.
Significant parts of scientific research are carried out on models rather than on the real phenomena because by studying a model we can discover features of and ascertain facts about the system the model stands for. This cognitive function of models has been widely recognized in the literature, and some researchers even suggest that models give rise to a new form of reasoning, the so-called 'model based reasoning' while modelling ability is also associated with model-based reasoning. It is well known that scientific theories are developed through a process of continuous elaboration and modification in which scientific models are developed and transformed to account for new phenomena that are uncovered .Similar processes are involved in students' learning of STEM concepts when they develop conceptual models (e.g. Bell et.al, 2010,Psycharis,2015;16). In a similar fashion, inquiry based learning requires students to make successive refinements to their mental models in order to transform them to conceptual models that align to scientific theories.
Simulation-based Engineering and Science is considered as the cognitive area that provides the Scientific and Mathematical basis for simulating

Natural Science and Engineered systems. According to (Xie et.al, 2011) computational models used for problem solving are the best way to create a curriculum that is both deeper and wider. Resorting to first principles in Physics and Mathematics to build educational tools may be considered as exaggeration by some researchers in STEM Education, but it is essential in order to bring learning experience related to authentic phenomena. Building models of simulation from first principles relies on the use of Computational Thinking (CT). Using the computational model approach, students write the mathematical relations they suppose that govern the problem, they select the simulation method, they develop the algorithm and finally they are engaging in writing source code using software or programming languages.

Institution name: E3STEM
Website: http://e3stem.edu.gr/wordpress/?page_id=121&lang=en

The Hellenic Education Society of STEM, (E 3 STEM), formed in 2017, is a registered, independent, nonprofit professional body and its members work for STEM education at primary, secondary and tertiary level.
E 3 STEM is a community of University Professors, School educators and School Advisors who share a common vision for the role of STEM epistemology in promoting education.E 3 STEM engages in the development of STEM applications and epistemology with practices linked to the Inquiry Based teaching and learning approaches. It aims to promote the STEM epistemology, computing, computational science and computational thinking, and to advance understanding and education of the STEM methodology alongside contemporary learning theories and didactic models. It is the only professional body for STEM education in Greece with the vision to grant chartered status to STEM in Education professionals.

Institution name: STEAM Greece
Website: https://www.steamgreece.com/

STEAM GREECE is a Non-Profit Organization that specializes in innovative STEAM and Robotics training programs. The design and implementation of the programs are undertaken by experienced and specialized executives, consisting of various specialties of scientists (educators, engineers, psychologists, etc.).

Institution name: STEM Education
Website: https://stem.edu.gr/%CE%BF-stem-education/

STEM Education conducts educational activities and aims for the STEM educational method to be inducted in the national education system. STEM Education is a non-profit organization and its purpose is:

- Create a proper environment where children of all age can develop their creativity, innovation and cooperation skills
- Develop applications of natural science and new technologies, focusing on applying educational robotics.
- Develop knowledge in Technology and improve performance in school, mainly in practical courses, such as mathematics, physics and computer technology.
- Encourage an open exchange of ideas and cooperation between the participants in the fields of technology and educational robotics.
- Include Engineering in natural sciences (STEM).

Institution name: STEAM Scientific Committee
Website: https://edu.ellak.gr/epistimoniki-epitropi-steam/

The goal of this Scientific Committee is to bridge the gap between the educational content and tools implemented in tertiary education and secondary education, respectively, to support the integration of STEAM education in the national curriculum.

Italy

Institution name: INDIRE

Website: https://www.indire.it/progetto/scientix/

INDIRE represents Italy and works to promote the use of Scientix in coordination and integration with the initiatives already activated nationwide. It also selects materials and projects produced in Italy to be published in the portal. Moreover, INDIRE promotes the launch of training initiatives related to the teaching of scientific subjects. Scientix is a project which promotes and supports European cooperation between teachers of STEM subjects (science, technology, engineering and math), researchers in pedagogy, policy makers and education professionals. The initiative is managed by the Network of Ministries European Schoolnet (EUN), on behalf of the European Commission. Scientix wants to ensure that the results of public funded scientific education projects can reach a wider audience, by collecting, sharing and disseminating educational materials.
The materials are mainly research reports and best practices from European scientific education projects funded by the European Union through the 6th and 7th Framework Programme for Research and Technological Development, the Permanent Learning Programme (LLP) or through other national initiatives. The platform is a truly engaging community, thanks to a database and tools to be used on and off-line. Scientix is translated into seven languages (English, French, German, Spanish, Italian, Polish, Romanian). EUN also provides an on-demand translation service in one of the 23 languages of the European Union. The educational materials, resources and scientific reports in the portal can be freely downloaded and reused. The platform offers, among other things, a search system for resources and published projects, as well as a series of social networking tools through which users can share their experiences with European colleagues.

Institution name: EDUIREN

Website: https://www.eduiren.it/

Eduiren is the educational sector of the Iren Group, one of the most important and dynamic multi-utility of Italian panorama. It provides different training and didactic offers, that are divided by theme - water, waste, energy - by type - activities, games, guided visits to plants, special projects - and by territorial area. It is dedicated to the declination of sustainability at 360 °. it is an inclusive, participatory, collaborative and creative way of structuring relationships with the local area sustainability issues. It is a catalog with

- 18 different lectures structured for different grades of schools
- 110 plants to visit
- 2 courses for teachers
- Educational games, materials and projects

It is a working group that supports educational projects on environmental issues promoted by schools and other subjects (Municipalities, Universities, Study Centers).
90,000 are Eduiren's annual contacts, i.e. at least 270,000 citizens of the territories in which Iren operates, not counting the Municipalities and Educational Institutes which were guaranteed free support to their educational policies and their

programs.
Eduiren supports each year about a hundred projects that arise from Local Authorities or other subjects present on the territory
This project aims to build a network of knowledge and fantasies for a continuous "Environmental Education 4.0". From school to the territory. Transversal and inclusive.
It also provides a teachers training offer, either through traditional lessons, creative moments and direct involvement.

Institution name: Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci
Website: https://www.museoscienza.org/en

The Leonardo Da Vinci National Museum of Science and Technology is today the leading technical-scientific museum in Italy and a center of excellence in Europe in STEM education. EDUCATION & CREI is now called its function dedicated to educational services. An internal and permanent structure composed of experts in the fields of science, scientific education, pedagogy, informal education, educational research who take care of all phases of the work, from the conception to the delivery of the museum's educational programs. Our educational activities are designed to give students the opportunity to experience science as a way to explore and interpret the world around us. We focus on STEM education for the development of 21st century skills from early childhood. We work to create awareness of the variety of existing scientific careers, with specific sensitivity to gender equality. We use innovative educational methodologies such as inquiry based learning, tinkering, making as powerful and inclusive tools for the development of basic skills building active citizenship.

Institution name: Istituto Nazionale di Fisica Nucleare
Website: https://artandscience.infn.it/

Art & Science across Italy is a European project of the CREATIONS network (H2020) organized by the National Institute of Nuclear Physics and CERN in Geneva to promote scientific culture among young people, combining the languages of art and science: two tools of knowledge among the highest expressions of human creativity.
The primary objective of the project is to bring students closer to the world of science and research, regardless of their aptitude for scientific subjects and initial knowledge, using art as a language of communication.
The project is structured in progressive steps with seminars in schools and universities, visits to museums and scientific laboratories, workshops held by experts from the world of science and art, and tutoring activities during the creation of artistic compositions. In particular, for each of the cities involved, the project is divided into a training phase and a creative phase, followed by a local exhibition and a final national selection that culminates in the exhibition "The colors of science - in the art of research scientific ", scheduled at the National Archaeological Museum of Naples, in the spring of 2020.
The winning students of the national artistic / scientific competition that concludes the project, selected by an international committee of experts, are invited to participate in a master on the subject of art and science, in September 2020, at CERN in Geneva and in other national laboratories. of research scientific ", scheduled at the National Archaeological Museum of Naples, in the spring of 2020.
The winning students of the national artistic / scientific competition that concludes the project, selected by an international committee of experts, are invited to participate in a master on the subject

of art and science, in September 2020, at CERN in Geneva and in other national laboratories.

Institution name: Museo dei Bambini
Website: http://www.mdbr.it

This "children museum" located in Rome provides several services and participates to several projects related to STE(A)M education for kids. Like "Made in Explora", a space for creating, experimenting and designing for schools, families and teachers, being part of the CREATIVE MAKERS: kids' fablabs for letterpress & printing inspired by tinkering and making (CREAM) project. Or "GARDENStoGROW: Urban Horticulture for Innovative and Inclusive Early Childhood Education", a "good practice" awarded Erasmus+ project. Its mission is:
to encourage and help the natural desire to learn of every child with stimulating,
entertaining proposals for children of all ages;

- to offer children and parents the opportunity to share this fascinating learning experience. Kids will grow up and parents will go back to their childhood;
- to provide teachers with new challenging experiences, for non-disciplinary learning, to be followed up by class activities;
- to attract interest and foster a well-disposed attitude towards culture, cooperation and respect for others and the environment;
- to let children and adults approach
- science and research promoting culture knowledge and new technologies

Institution name: ISIS MACHIAVELLI
Website: http://www.liceomachiavelli-firenze.gov.it

This secondary school (liceo) from Florence coordinated the "good practice" awarded Erasmus+ project "Do Well Science", whose general objective has been to increase secondary students learning remarussiapastacaldi@gmail.comsults in STEM (maths, physics and natural sciences).
While the specific objectives were:

- Provide valuable support to STEM teachers in promoting an interdisciplinary and inquiry-based learning approach to increase students capacity in problem-solving, critical thinking, active research and curiosity towards scientific subjects
- Develop innovative pedagogies for science teaching and learning based on the use of youngsters most diffused communication and information tools as apps for smartphones and tablets and the web
- Make full use of ICT communication potential to promote among students a cooperative based and peer to peer

learning practice in order to stimulate their commitment to learn scientific subjects.

Institution name: Water Right Foundation
Website: http://www.wrf.it/

Water Right Foundation promotes development cooperation projects, information, awareness and environmental education interventions. Spread of a culture of water and a sustainable use of resources. It recently coordinated the "Daylighting Rivers" Erasmus+ project, that engaged secondary school students in Italy, Greece and Spain in hands-on, interdisciplinary investigations of the riverways that flow through the city with an emphasis on ecosystems, management, threats and their impacts.
The students undertake activities rooted not only in physical science, by considering environmental impacts on soil, climate and biodiversity, but also in the historical, social and economic aspects of urban rivers. In our project, Daylighting Rivers means not only re-exposing covered rivers to the light but also

raising environmental awareness and stimulating active citizenship.
The project has developed a cyclic methodology based on Inquiry-Based Learning that fosters the use of technologies for investigating the environment and the development of soft skills such as group work and communication.

Cyprus

Institution name: STEMFREAK Centre for Science, Technology, Knowledge and Personal Development
Website: https://www.stemfreak.com/

Project Objective: The promotion of STEM and the development of scientific and technological literacy for the sustainable development of Cypriot society and economy. We aim to develop and certify the skills of the 21st century so that our graduates acquire the skills they need to be competitive in the labour market. We aim to develop the knowledge, skills and personality quality of our students in a fascinating learning environment.

Institution Name: STANDO LTD
Website: https://www.standoutedu.com/

STANDO LTD is a research and educational organisation based in Cyprus, dedicated to the advancement of research and innovation. We are, at the same time, an approved VET Centre accredited by the Human Resource Development Authority of Cyprus. The strength of our enterprise primarily lies in our highly qualified team and its extended network of international partners. Our dynamic and experienced academics, researchers and practitioners are committed in implementing large scale co-funded projects and collaborate with organizations from Cyprus and around the world. We actively participate in the planning and implementation of national and international projects, aiming at providing innovative solutions that facilitate the development of people and the cohesion of societies. Since 2016, we are providing a series of professional and academic trainings under the scope of Erasmus+ KA1 and KA2, as well as courses, seminars and consulting services to various target groups (students, youths, teachers, policy makers, parents, adults), learners and staff of Vocational Education and Training (VET) providers and Adult Centres.

Institution Name: The Grammar School Nicosia
Website: http://gigstem.weebly.com/the-grammar-school-nicosia-cy.html

By establishing a private, English speaking educational institution fifty five years ago, the Grammar School founders gave the opportunity to students in Cyprus to broaden their knowledge and their educational horizons by giving them the opportunity to continue their education in any country in Europe or the world. The Grammar School offered a high standard education and our vision was to become one of the leading private schools in Cyprus, a goal we are proud to have achieved.
The Grammar a Schools make up an educational community of students, parents and staff where learning happens at its best. We strive to be at the cutting edge of education using innovative technologies and teaching methods to enable our students to unlock their potentials and achieve personal, social, cultural and academic growth.

Institution Name: Neapolis University Pafos
Website: https://www.nup.ac.cy/research/csrc-cyprus-science-research-center-centre-for-steam-education-research-

science-communication-and-innovation-teaming-horizon-2020/

This is the first time that the island's universities are joining forces to create a Center of Excellence and Innovation in Cyprus, in cooperation with Cypriot companies. They include the University of Cyprus (UCy), the University of Technology (CUT), the Open University Cyprus, University of Nicosia, European University Cyprus, UCLan Cyprus, Neapolis University Pafos and Frederick University of Technology. The €400,000 in funding will enable the project to develop a business plan for the creation of the Cyprus Science and Research Centre, which would benefit Cyprus and the broader region.

Institution Name: Heritage School Limassol
Website: https://heritageschool.ac.cy/extracurricular/projects/

SLAM-STEM Learning Activities & Methods: Lower Secondary Schools Fran Koncelak School in Croatia, partnering with 2nd Gymnasium of Nea Ionia Attikis in Greece, Tartu Raatuse School in Estonia, and The Heritage Private School in Cyprus. Recent research has indicated that students' skills in Mathematics and Science require enrichment globally. Therefore, the SLAM-STEM project pledges to develop students' capabilities in these areas by modelling good practice.

Institution Name: Thales Foundation
Website: https://thalescyprus.com/

Our mission is the recognition of academic excellence and to facilitate the young people to express their talent. This will be accomplished through the organization of activities that promote the harmonious development of youth using non-formal education, by stimulating their creative and applicative thinking, the intuition, the imagination, the discovery and innovation, the ability to select and to make decisions. In addition we aim to promote the learning and use of European languages and the strengthening of cultural links between the European countries. We invite people of all ages who are interested in the above to become members of our Foundation. The THALES Foundation is a non-for profit organization registered in Cyprus with a goal to become one of the most dynamic educational organizations in the region.

Institution Name: Cyprus Computer Society
Website: https://ccs.org.cy/en/

The Cyprus Computer Society (CCS) is a professional, scientific and independent non-profit organization, founded in 1984 with the aim of developing, upgrading and promoting the IT sector in Cyprus. CCS seeks to set high standards among industry professionals, recognizing the impact that Information and Communication Technologies (ICT) has on employment, business, society and the quality of life of the citizens.
Playing a key role in connecting academics with the professional sector, the Association promotes key issues in the industry, especially in the fields of digital literacy, professional skills, professionalism, education, training and research.
As the foremost body for the promotion of the ICT sector, CCS expresses its views on behalf of its members to national authorities on strategic ICT issues and participates in European and other projects by developing multilateral partnerships with the academic community, governmental, public, private and non-governmental organizations. In collaboration with stakeholders, and with the contribution of valuable volunteers, the Society undertakes activities, events and competitions held for the benefit of professionals, teachers, students, pupils, and friends of ICT in Cyprus.
The Association currently represents more than 1000 members, professionals and ICT students, while thousands of people, children, young people,

Activity 1.4

STEM Philosophy and Outcomes

Partner responsible:

AMETA – association for European mobility and training

Description of STEM: The word STEM (Science, Technology, Engineering and Mathematics) is an acronym which stands for the fields of science, technology, engineering and mathematics in the education process. The biologist Judith A. Ramaley, a head of the U.S. Natural Science Institution, was responsible for creating new educational programmes in 2011, first used this concept.
STEM is an approach that combines technology and engineering, along with science and mathematics, which are essential to understand the laws of the universe. The University of Colombia stated that we need to answer the basic question "How can we give such a meaning to education so that children would want to remain at school, improve their performance and graduate high school with the proper knowledge in order to start their academic education and enter working market?"
The response to this question is simple: students will have to be adequately trained to realize that their own prosperity depends on the nature of the entire world in which they live, i.e. they should be educated and aware about the matters such as climate change, renewable energy sources, natural environment, sustainability, etc. A highly educated nation has to face the demands of daily life and innovate.
Throughout Europe, countries that aim to develop their industry, try to induct STEM in their education systems. To this direction, in 2009 begun an effort in the European school network, based in Brussels, so that some of the schools would develop pilot activities and technologies in the classroom, exploring the use of educational material in teaching STEM. Stem education is an attempt to evolve from the tutor-centered approach into a teaching method that involves problem solving, creative initiative, research and hands-on activities. STEM offers a chance for children to develop their abilities encouraging then to answer questions and get involved with fun activities based on science, mathematics, engineering and technology. It is truly impressive how the children react to this method, as they seem to find it more interesting and appealing. By applying STEM through various projects, students learn to process facts and focus on solving problems and gain abilities fitting to global education, develop critical thinking and work in a team, while it has also been reported that the knowledge gap between children from different countries has significantly been decreased. In this philosophy, a new project was born, called " STEM on the road" aiming to initiate social awareness and ensure everyone's involvement in achieving real increase in children's performance in science, technology, engineering and mathematics.
The philosophy of STEM is rooted in exploration, teamwork, and inclusion. STEM fosters an environment where participants learn by doing, overcoming challenges of problem solving and

and valuing the input of others. The role of mentors as guides to learning is very important, to design activities in any STEM center or corner that are inclusive and engaging for everyone. At the end of the proposed STEM activities the students need to have acquired skills in STEM, basic and transversal, as self-carer oriented, digital skills, high quality resources and opportunities for project-based, real-world learning. The Problem-Based Learning (PBL) as a teaching method needs to be applied. In it, the complex real-world problems are used as a vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts.

As these activities have not been introduced within the national curriculum in many countries, the teachers have been running STEM afterschool programs, sometimes referred to as out-of-school time programs, during non-school hours, which include before school, after school, on weekends, and in the summer. In some instances afterschool programs are linked to formal education, other times they are independent. There have been eight principles of effective afterschool science programs identified:

- are for all students;
- are intentional and standards-based;
- are active, interesting, and relevant to students;
- reflect current research and practices;
- are age-level appropriate;
- integrate skills from different subjects;
- incorporate staff training in science teaching; and
- are based on ongoing assessment of student needs and progress.

However, these principles may apply more or less, depending on the relative emphasis of academic outcomes versus youth development.

Outcomes of STEM after school programs

The afterschool field has developed a number of and indicators for afterschool programs in general (Partnership for After School Education, 2010; The Forum for Youth Investment & National Collaboration for Youth Research Group, 2012; Wilson-Ashlstrom, Yohalem, DuBois, Ji, & Hillaker, 2014). In 2011, the Afterschool Alliance reviewed 19 evaluations of STEM afterschool programs and identified outcomes common to these programs. They categorized the findings of these evaluations into three overarching outcome categories. For each outcome, they identified impacts common across a number of the evaluations (listed below each outcome category).

1. Improved attitudes toward STEM fields and careers.
- Increased enrollment and interest in STEM-related courses in school
- Continued participation in STEM programming.
- Increased self-confidence in tackling science classes and projects.
- Shift in attitude about careers in STEM.

2. Increased STEM knowledge and skills.
- Increased test scores as compared to non-participants.
- Gains in 21st century skills, including communication, teamwork, and analytical thinking
- Gains in knowledge about STEM careers.
- Gains in computer and technology skills.
- Increased general knowledge of science.

3. Higher likelihood of graduation and pursuing a STEM career
- High rate of high school graduation among participants.
- Pursuit of college and intention of majoring in STEM fields.

In 2013, the Afterschool Alliance worked to further define outcomes for STEM afterschool programs. They carried out a consensus study with experts that included afterschool providers and afterschool STEM supporters to identify outcomes specific to STEM learning in afterschool programs. The study resulted in a consensus set of outcomes, indicators, and sub-indicators. The three overarching outcomes state that through STEM afterschool programs, children and youth:

1. Develop an interest in STEM and STEM learning activities.
2. Develop a capacity to productively engage in STEM learning activities.
3. Come to value the goals of STEM and STEM learning activities.

As described in the report, "the outcomes, indicators and sub-indicators identified through this study are intended to help provide a common framework and language for programs to utilize as they define appropriate goals for their programs and then describe the impact of their afterschool STEM program

Main Motivations regarding STEM reforms

1. Digital culture for the citizens of the future

The rise of the digital economy has made knowledge related to ICT, coding, robotics, etc. necessary for current citizens but even more so for future citizens. To face this challenge, European countries are reforming their STEM curricula to introduce courses to encourage digital skills. The traditional mission of a national education system, "training future citizens and citizens for the future", is a challenge that is becoming increasingly complex. The pace of technological change is accelerating, controversies are multiplying (eugenics, privacy, nanomaterials, etc.) and teachers need to update their expertise more frequently. It is precisely this technological expertise that seems to be lacking within organisations, companies and education systems. If the national education system is not able to adapt to the pace, the whole country will lag behind.

2. Attracting students to STEM for the job market

European countries are implementing strategies and initiatives to increase the popularity of STEM studies and careers.

One of the main motivations for improving STEM education is the need to attract more students into STEM studies to provide the job market with adequate resources, in terms of quality and quantity. However, this motivation lacks a coherent and integrated approach:

- **some countries are focusing on ICT for primary and secondary education, mainly coding projects (designing games, programming robots, etc.), which do not necessarily develop skills related to research and development activities that an engineer would require;**
- **the well-known fact that employers depend on universities that in turn depend on high schools to recruit STEM skilled candidates does not seem to inspire national STEM strategies, which involve an ambitious cooperation between these three types of actors.**

National Approach

A truly harmonised national approach must be put in place to coordinate numerous and diverse partnerships or internal programmes in favour of STEM. STEM initiatives should be connected to the curriculum or fully integrated into schools' local strategies for measuring their impact on student success and therefore their overall efficiency. While a variety of approaches is needed, the lack of a coordinated approach also appears when one looks at the heterogeneous partnerships between high schools and universities and companies.

Activity 1.5

Choosing Curriculum and Classroom Management

Partner responsible:
Martna Pohikool, secondary school – Estonia

Choosing curriculum

Nowadays we are able to access to different STEM curricula via online. Universities, technology companies, robotics manufacturers and different web application environments have made them easily accessible.
You can access to Curricula via different online platforms such as:
Tynker - www.tynker.com
Code - www.code.org
Lego Education - https://education.lego.com/en-us/lessons
STEMpedia - https://thestempedia.com/curriculum
TeachEngineering - https://www.teachengineering.org

How to make right choices to implement the STEM curriculum?
You can create a curriculum by yourself or choose one from the existing ones. There are many factors to consider when you create curriculum or adopting one created by someone else

- Difficulty of the curriculum should be adequate to the age of students and keep them active

- Make sure that the length of your lessons plan suits with the length of the lessons at your school
- Identify which technological tools are available in your school
- Find out what are your school's financial resources in order to provide missing yet necessary tools
- Make sure that the physical size of the classroom is adequate
- Before you start teaching STEM subjects, ask your students what are their expectations and interests
- Choose what activities you are capable to guide and are interesting to you as well
- Be familiar with the existing curriculum of the school, you will definitely find topics that you can use to prepare your lessons and integrate the topics into your lessons

Selection of appropriate activities

Consider the age group of students you are guiding - many STEM activities are suitable for different age groups, however the level of the tasks needs to be changed. For example, distance and speed problems can be solved more playfully in grades I-II if there are compact robots such as MeetEdison, TTS Rugged Robot or a simple Milo model from LegoWedo with a simple visual programming language what lets students derive formulas based on test results. Teacher's guidance on how to format the test results is necessary. For the older group of participants, the teacher can give more time to improve the construction and design of prototypes of more sophisticated robotic devices. Find the impact of mass to speed and distance. Of course, there are lessons that are not suitable for all age groups. Younger students can find tasks where a lot of proof and use of argumentation is needed challenging. For younger students, the construction of the water filter is easy, but measuring water turbidity with a Vernier turbidity sensor, collecting data with a Vernier data collector and drawing conclusions from it is possible too challenging. This exercise should be used from the third school level onwards. Sometimes the choice is based on time. Some learning activities may not be suitable because they take too much time and using the classroom for a longer period of time is not possible. Sometimes, the classroom is not suitable, for example there is not enough space to conduct experiments. Some activities require materials that can be expensive or difficult to obtain, such as batteries, different robotics kits or different sensors.

Mapping of interests, needs and comparison with the current school curriculum

Before using the curriculum identify students, their parents and community preferences. Find a lot of common interests in mapping, that way the rate of engaging in activities can be higher.

Be sure to be familiar with the school's current curriculum and find out which STEM subjects are covered in which classes. Integrate these activities into your curriculum experiments. However, when reviewing major curricula, you come to the conclusion that some topics of the science subjects are not taught at all, add them to your curriculum.

Classroom management

You certainly don't want noisy, disruptive students in your class. There are many different ways to keep students engaged. Of course, it must be considered that you will never achieve complete peace and silence in your lessons. Group work and discussions between students will definitely bring some noise into the classroom, but this is a work atmosphere.

How do you achieve an atmosphere of constructive work?

Rule 1: good friendly relations

Good relationships should exist between everyone in the classroom. In the first lesson be sure to take time and introduce yourself, do some relationship-building warm-up exercises. In the first lesson, agree on the rules for the class, have the students formulate these rules themselves. Set the rules for how a student asks for help, speaks out loud, how to clean up his / her workplace after studying, etc. The rules should be positively worded and in self-form. Eg 1) I am friendly; 2) I cooperate; 3) At the end of the class, I will clean up my study place, etc. Be sure to agree on what happens if the rules are not followed. Put these rules in a visible place in the classroom.

Rule 2: get involved

Participate in experiments, build models, take turns as a member of different groups. However, it must not be forgotten that you must be able to supervise students from other groups if necessary. Be enthusiastic and believe in what you are teaching. If you do not believe in what you are teaching, students will also realize that you have no interest and that everything is done for the sake of the "tick".

Rule 3: You need to have a good plan

Prepare for the lessons, be sure to do the experiments by yourself in advance, solve the tasks. By doing so, it is quite likely that you will encounter the same problems as the students, so you will be prepared when solving the tasks with students. Be sure how many specific tasks you will give to students and how much you let them discover for themselves. It helps to make the lesson more successful if you have a lesson plan where you have written down the goals of the lesson, the main activities, the time limit for these activities and it would be useful to have a list of materials needed.

Used resources

1)The-Global-STEM-Toolkit, World Learning (2020) www.globalstemlearning.org (February 2021)

2) S. Hendrikson, Tehnoloogialase huviringi juhendamine https://drive.google.com/file/d/0B9wbCGaN-Xe2dzFjRWxBMnRfT2M/view (February 2021) .

Activity 1.6

Examples of good practices

Lesson plan scenarios with STEM activities

Partner responsible:
Agios Georgios Lyceum - Cyprus
DOUKAS School - Greece
Martna Pohikool, secondary school - Estonia

Lesson plan scenario 1

1. OVERVIEW

Lesson Topic Estimating the size of a molecule using an oil film

Content Areas Chemistry, Physics, Mathematics

Duration of Lesson 90 minutes

Target grades/ Age 15- 16 years

Brief description of the lesson

We will investigate through an experiment how oil mixes with water and how an oil spill develops and to measure the size of an oil molecule. The activity is closely related to the pollution of the sea.

2. LEARNING OBJECTIVES

General objectives

The purpose of the activity is to measure the size of the oil molecule with simple materials: olive oil, water, small volumetric container, eyedropper, ruler, fine powder/lycopodium powder (dried pollen), large dry tray, calculator.

Particular objectives

The activity enables students to synthesize knowledge and skills from many fields: physics, chemistry, mathematics, and environmental studies to study a realistic problem (pollution from oil spills).

21st century skills gained

The atomic and/or molecular structure of matter (otherwise kinetic theory of matter) is one of the basic concepts of science at all levels. Knowledge of the size of atoms/molecules is important and necessary for a better understanding of the importance of atomic theory.

3. METHODOLOGY

Teaching methods

- Teacher 1 (EC1): Teacher of Physics - Teaching of the Atomic Theory of Matter - Classroom
- Teacher 2 (EC2): Teacher of Chemistry - Teaching oil-water interaction - Shape of oil molecule
- Teacher 3 (EC3): Teacher of Mathematics - Teaching geometric volumes - processing of algebraic formulas - proportions.
- The coordinator may be the Teacher of Physics.

Teaching techniques

Discussion, problem solving, experiment, mathematical calculations

Prerequisites Kinetic/atomic theory of matter, basic behavior of oil on water, shape of oil molecule, simple algebraic manipulation

Materials

Whiteboard/interactive board/flipchart, computer with appropriate software, student handout(s), laboratory with suitable equipment

(large shallow tray, clean water, olive oil, fine powder/lycopodium powder, dropper, ruler, means of disposing used water)

Resources used by the teacher

Whiteboard/interactive board/flipchart, computer with suitable software, videos, handouts, laboratory

Resources for the students

Physics/Chemistry/Mathematics teachers, handouts, laboratory

4. IMPLEMENTATION (organization of the lesson)

Introduction/ Motivation

Activities of the teacher(s)and students

(creation of interest, reference to real value issues, relation to background experiences etc)

- Discussion of issue (oil spillages / sea pollution)
- Discussion of background knowledge
- Discussion of main activity

Main Activity

Activities of the teacher(s)and students

Development activities (preparation for practice)

- Demonstration of equipment and discussion of procedure
- Safety precautions
- Discussion of mathematical procedures

Practicing activities (guided practice ->free practice)

- Students carry out the activity
- Teacher supervises activity
- Students work on handout and draw conclusion(s)

Reflection/Closing Activity

Activities of the teacher(s)and students

- Students submit results to the teacher
- Teacher summarizes results and guides students to draw final conclusion

5. EVALUATION / ASSESSMENT

Assessment Type: (what is measuring, assessing)

-Teacher assesses experimental skills and group-work skills during activity

-Teacher assesses critical thinking and mathematical skills through handout

*Pre-Activity, Activity-Embedded, Post-Activity Assessment

Evaluation tools (instruments)

Activity handout (formative assessment), Synoptic and summative written assessment (test) after concluding the activity

6. Real-world application

- where it can be applied
- design questions to put the students in real – life situations
- invite guest speakers
- real world research

7. Assignment

Study a specific oil spillage in the sea near Cyprus and how it was dealt with by the authorities. Report the results of the study to the class.

Author(s): George Chimonides

Lesson plan scenario 2

1. OVERVIEW

Lesson Topic Lifebuoy saves lives when needed

Content Areas Physics, Mathematics, IT

Duration of Lesson 90 minutes

Target grades/ Age 15- 16 years

Brief description of the lesson

We will investigate how to minimize the time needed for a lifebuoy starting from a specific point on the perimeter of a pool to reach a particular point in the pool.

2. LEARNING OBJECTIVES

General objectives

To enable students to apply their knowledge of uniform linear motion in a novel situation. To learn how to find an optimal solution by solving a minimization problem.

Particular objectives

To train the students in the use of interactive applets, for computational approaches to the problem

21st century skills gained

TComputational methods as an integral mathematical tool and the use of interactive applets to facilitate computation.

3. METHODOLOGY

Teaching methods

- Teacher 1 (EC1): Teacher of Physics - Teaching of uniform linear motion and/or uniformly accelerated motion - Classroom
- Teacher 2 (EC2): Teacher of Mathematics - Teaching optimization problems - Classroom
- Teacher 3 (EC3): Teacher of Mathematics or IT teacher - Teaching how to transform a problem to an interactive applet and how to approach the solution with computational methods – IT Lab
- The coordinator may be the Teacher of Mathematics

Teaching techniques

Discussion, problem solving, experimentation, mathematical and computational calculations

Prerequisites

Students are taught the calculation of distance and time in uniform linear motion

Material

Whiteboard/interactive board/flipchart, computer with appropriate software, student handout(s), calculator

Resources used by the teacher

Whiteboard/interactive board/flipchart, computer with suitable software, videos, handouts, laboratory

Resources for the students

Physics/Chemistry/Mathematics teachers, handouts, graph paper, calculator

4. IMPLEMENTATION (organization of the lesson)

Introduction/ Motivation

Activities of the teacher(s) and students

- Development activities (preparation for practice)

  - Students are divided into groups and asked to formulate thoughts and arguments to make a layout plan

  - Carry out appropriate calculations

  - Decide the procedure that will lead them to the optimal solution sought (for example experimentation)

- Practicing activities (guided practice ->free practice)

  - Students carry out their plan

  - Teacher supervises activity

  - Students work on handout(s) and draw conclusion(s)

Main Activity

Activities of the teacher(s) and students

- Development activities (preparation for practice)

  - Students are divided into groups and asked to formulate thoughts and arguments to make a layout plan

  - Carry out appropriate calculations

  - Decide the procedure that will lead them to the optimal solution sought (for example experimentation)

- Practicing activities (guided practice ->free practice)

  - Students carry out their plan

  - Teacher supervises activity

  - Students work on handout(s) and draw conclusion(s)

Reflection/Closing Activity

Activities of the teacher(s)and students

- Students submit results to the teacher

- Teacher summarizes results and guides students to draw final conclusion

5. EVALUATION / ASSESSMENT

Assessment Type: (what is measuring, assessing)

-Teacher assesses design skills and group-work skills during activity

-Teacher assesses critical thinking and mathematical and computational skills through handout

*Pre-Activity, Activity-Embedded, Post-Activity Assessment

Evaluation tools (instruments)

Evaluation tools (instruments) Activity handout (formative assessment), Synoptic and summative written assessment (test) after concluding the activity

6. Real-world application

- where it can be applied

- design questions to put the students in real – life situations (the Least Action Principle in Physics can be discussed as a generalization)

- invite guest speakers
- real world research

7. Assignment

-Study behavior of light as an extension

-Ask students to consider other cases of minimization/maximization

-Report back to the class

Author(s): George Chimonides

Lesson plan scenario 3

1. OVERVIEW

Lesson Topic COVID-19 Vaccines, different types, efficacy & methods

Content Areas Mathematics, Biology, Science

Duration of Lesson 5 lesson hours (5*45 minutes)

Target grades/ Age Grades 9-12 (Ages: 15-18)

Brief description of the lesson

This lesson plan relates to COVID-19 and its vaccines, students will learn the different types of vaccines produced during this period, their efficacy and the different methods on which their production is based.

2. LEARNING OBJECTIVES

General objectives

Approach the COVID-19 vaccination process from a STEM point of view.

Particular objectives

Mathematics: statistical comprehension of the impact of the vaccination.

Biology: understanding the different types of vaccines, how they work and the conditions under which they should be kept.

Technology: develop a simple algorithm (annex, search, input, print) to handle a country's vaccination process.

21st century skills gained

real-world problem solving, digital skills, STEM skills

3. METHODOLOGY

Teaching methods

demonstration, project based, brainstorming, presentationTeaching techniques

Teaching techniques

real-world problem solving, student-centered

Prerequisites

basic knowledge of statistics (math), viruses and cellular biology

Materials

presentations, infographics, classroom activities, resources

Resources used by the teacher

presentation (ppt), infographics, students' books, (optional: fake programming language software provided by the national ministry of education or a basic programming tool e.g. C, Pascal, etc.)Resources for the students

Resources for the students

students' books, teachers' presentations, infographics, digital device (laptop, tablet, mobile phone, etc.)

4. IMPLEMENTATION (organization of the lesson)

Introduction/ Motivation

Activities of the teacher(s)and students

Activities of the teacher(s) and students (creation of interest, reference to real value issues, relation to background experiences, etc.)

- presentation of the COVID-19 pandemic
- comparison with other global past pandemics
- importance of vaccines to human kind & the difference they have made to the world
- presentation of the current vaccination phase, how many different vaccines were produced, which methods have been used, the process of their production, transfer and storage
- presentation of the vaccines infographics

Main Activity (135 min)

Activities of the teacher(s) and students

Students should carefully read and interpret the information presented in the infographics. The information provided by the infographics will be crucial to the following activities of the lesson plan.

1st Activity: Mathematics – Probability

- students will be separated into teams and assigned with a specific vaccine
- the teams of students will be asked to imagine how they could calculate the percentage of immunity of a population given that a known percentage has been vaccinated by a singular vaccine with a known percentage of efficacy for one of the COVID-19 types.
- the teams will present their thought process and the teacher will present the proper way of calculating it enabling students to reflect on the process they suggested
- the teams will now calculate the percentage of immunity
- after each team presents their results they will all discuss them as a whole classroom activity
- teacher will explain why there is a need of multiple vaccines

2nd Activity: Biology – Cellular Biology & Viruses

- teacher will present the basics of cellular biology, explain the way vaccines work in general
- teacher will present the types of vaccines and how they work with our immune system to protect us from the viruses
- students will work in teams, research the different vaccines and present the way they effect our immune system to achieve a percent of immunity
- the teams will present their findings by answering the following questions:

• What method does each vaccine follows?
• How this process effects its transfer and storage?
• Is there a relation between the method and the efficacy?
• Were both methods well-known to humanity or is one relatively new?

3rd Activity: Technology – Algorithms

- Students will be presented with the following project:

• Develop an algorithm that will define a table for X population with the appropriate fields (name, age, phone number, days until vaccination). Each day the vaccination center may perform 100

vaccinations. The user will input their name, age and phone number. The algorithm will check the value validity of the age (60+ years old), will search the table for the first empty row and will input the user data and output the days until vaccination (as soon as possible) and the following message "Dear Mr/ Mrs (name), you will be vaccinated in (days until vaccination) days."

Reflection/Closing Activity (45 min)

Each student will present what they have learnt and what has made a big impression on them. Express their positive/ negative feelings on the progress of the vaccination process at a global level. Present the experiences of their acquittances that have been vaccinated and their algorithm.

The teacher will close the lesson by presenting students with the global COVID-19 statistics and the way students can interpret them.

5. EVALUATION / ASSESSMENT

Assessment Type: (what is measuring, assessing)

skills (problem solving skills, teamwork skills, critical thinking); learning objectives; formative assessment (understanding of contents); peer assessment;

Evaluation tools (instruments)

presentations of the projects, google presentations, kahoot quizzes

6. Real-world application

- global application
- real life situation projects
- real-world facts and information research

7. Assignment

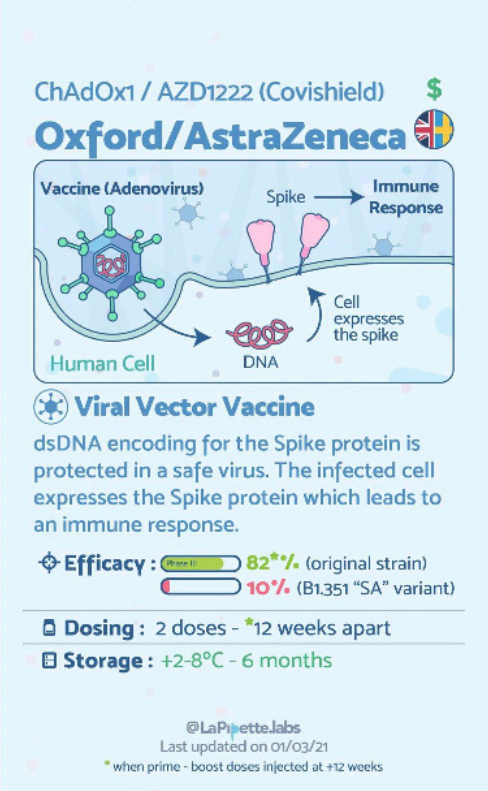
- Activity 1: team project
- Activity 2: team project
- Activity 3: personal project

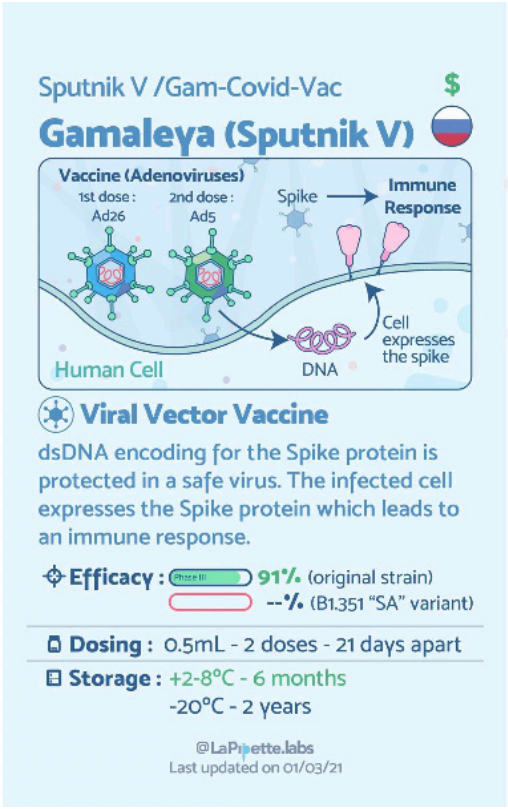
8. Extension

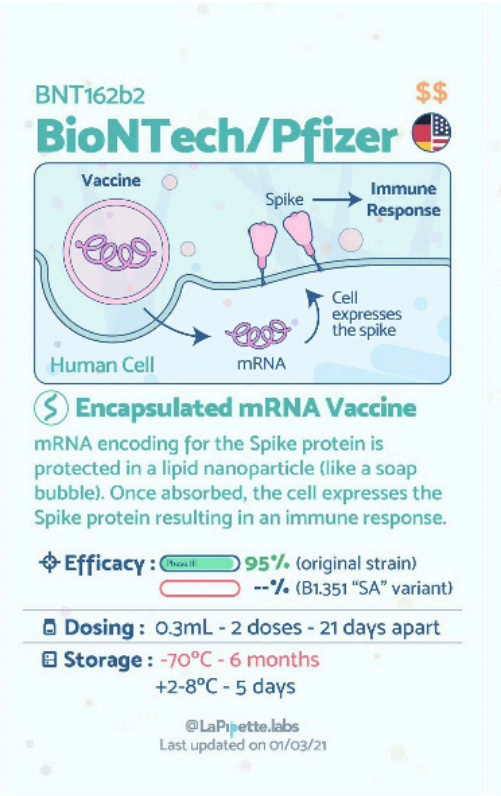
- mathematics: comprehension and introduction to arithmetic and geometric progress
- biology: how COVID-19 infects the body, comprehension of incubation period and the period that a virus is most contagious
- technology: make two appointments for the vaccines that require two doses

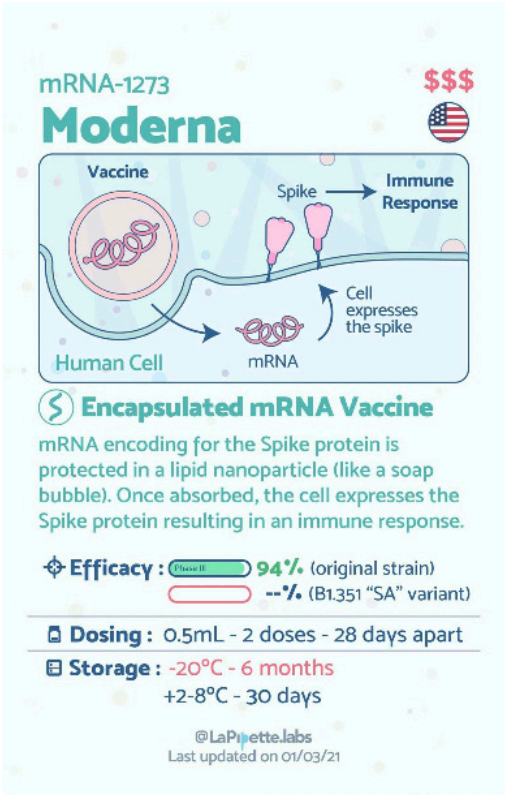
Author(s): Thomas Economou, Elpi Margariti

Lesson plan scenario 3 - Infographics



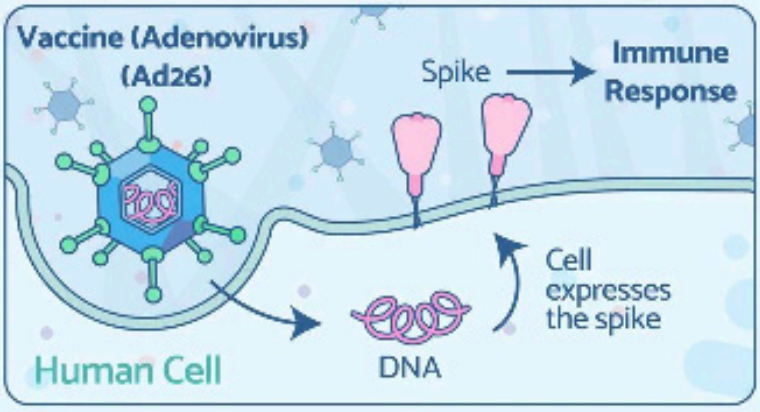






JNJ-78436735 / Ad26.COV2.S $

Johnson&Johnson



Viral Vector Vaccine

dsDNA encoding for the Spike protein is protected in a safe virus. The infected cell expresses the Spike protein which leads to an immune response.

Efficacy : moderate to severe cases
Phase II — 72% (original strain - US)
Phase III — 57% (B1.351 "SA" variant)

Dosing : 1 dose

Storage : +2-8°C - 3 months
-20°C - 2 years

@LaPipette.labs
Last updated on 01/03/21

Lesson plan scenario 4

1. OVERVIEW

Lesson Topic Labyrinths, mazes, paths and routes

Content Areas History, Mathematics, Algorithms, Robotics, Geographic Space, Wooden Constructions

Duration of Lesson 90-120 minutes (at minimum of 2*45 min)

Target grades/ Age Grades 6-9 (Ages: 12-15)

Brief description of the lesson

Designing and following paths and routes in our real life, with a starting point and a destination, is a common practice. Getting out of a building with a labyrinthine design can be especially difficult if we are not observant or we do not have some help. The four simplified activities described in this lesson plan are related to the previous examples and start from the 2000-year-old problem of finding a path in the labyrinth of Knossos Palace, to the current 4000+ year later hot problem, of driving a robot to the surface of Mars, around a crater.

2. LEARNING OBJECTIVES

General objectives

Development of general algorithmic thinking skills

Particular objectives

Science: develop geo spatial literacy utilizing location and spatial paths

Technology: develop simple algorithms to handle labyrinth and routing problems.

Engineering: construct simple modular wooden pieces or a robot at least with 3 wheels

Mathematics: solve problems with calculations and expressions as well design geometrical shapes

21st century skills gained

Real-world problem solving, digital skills, STEM skills, solving problems using algorithms

3. METHODOLOGY

Teaching methods

Demonstration, brainstorming, presentation, project based

Teaching techniques

real-world problem solving, student-centered

Prerequisites

Basic knowledge of calculations and expressions (math), introductory algorithm concepts (compute science)

Materials

- Maze history: https://www.ancient.eu/Labyrinth/
- Maze Generator: http://www.mazegenerator.net/
- App: Mazes & More (Android) https://play.google.com/store/apps/details?id=com.leodesol.games.classic.maze.labyrinth (https://maplemedia.io)
- App: Rail Maze (Android & IOs)
- https://www.spookyhousestudios.com/s/2015/11/04/rail-maze-train-puzzler/

- Scratch or other programming language: https://scratch.mit.edu
- Scratch "Core Code": https://scratch.mit.edu/projects/481599033
- Infographic "Core Code": https://www2.slideshare.net/EISTEAMProject/infographic-core-code
- Maze solvers: https://en.wikipedia.org/wiki/Maze-solving_algorithm
- Wooden maze construction (from sources for Thymio robot) https://www.youtube.com/watch?v=K8oi02JW0hQ
- https://solarsystem.nasa.gov/planets/mars/in-depth/
- https://mars.nasa.gov/mars2020/mission/where-is-the-rover/

Resources for the teacher and the students

- Digital device (laptop, tablet, mobile phone, etc.)
- Robot with wheels (optional) or/and the Scratch application
- Wooden pieces (optional, for maze construction)

4. IMPLEMENTATION (organization of the lesson)

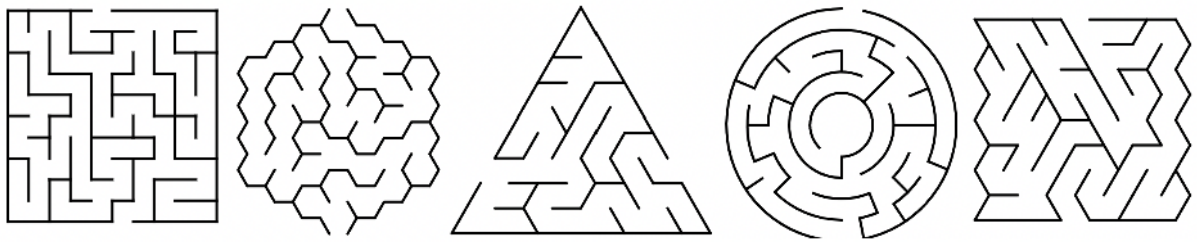
Introduction/ Motivation (10-15 min)

Introductory activity of the teacher(s) and students:
The 2000-year-old and most famous labyrinth myth is the Greek story about Theseus and the Minotaur in Knossos, referring to the Minoan civilization. Students can search and interpret the information of the story and explain the meaning of the labyrinth.

Ancient History Encyclopedia: Labyrinth & Minotaur

Main Activity (70-90 min)

1st Activity: Geometry - Maze generator



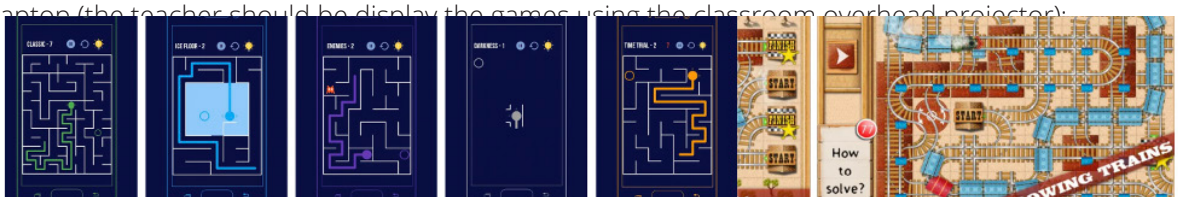
www.mazegenerator.net

The following could be some of the problems that the students could solve according to the 4 shapes of the generator (rectangular in 3 different styles, circular in 1 style, triangular in 1 style and hexagonal in 2 different styles) and at least with the 3 main parameters (side length, inner length and starting position):

- Generate 7 different maze shapes & styles, e.g., using a length of 10 cells and solve the corresponding maze. Is there a second solution?
- Calculate for the same width/height/side/diameter length of 20 cells with 0 inner cells (according to the terminology of the generator) the total number of the four main shapes (rectangular, circular, triangular, hexagonal).
- Try to describe a general algorithm for solving any kind of the above mazes.

1st-b Activity (optional): Problem solving - Playing with a Maze app

Install and play with the following two apps in our smartphone or tablet, or with an emulator to your laptop (the teacher should be display the games using the classroom overhead projector):



- Mazes & More App (Android): https://play.google.com/store/apps/details?id=com.leodesol.games.classic.maze.labyrinth
- Rail Maze App (Android & IOs): https://www.spookyhousestudios.com/s/2015/11/04/rail-maze-train-puzzler/

2nd Activity: Computer Science - Maze algorithms

Is there any difference between the terms "labyrinth" and "maze"?

According to Wikipedia: "A maze is a path or collection of paths, typically from an entrance to a goal. The word is used to refer both to branching tour puzzles through which the solver must find a route, and to simpler non-branching ("unicursal") patterns that lead unambiguously through a convoluted layout to a goal. The term "labyrinth" is generally synonymous with "maze", but can also connote specifically a unicursal pattern.".

There are a lot of algorithms that solve a maze problem. Examine the pros and cons of the following simple ones:

- Random mouse algorithm: follow the current path until a junction is reached, and then make a random decision about the next direction to follow.
- Wall follower: If the maze is simply connected, that is, all its walls are connected together or to the maze's outer boundary, then by keeping one hand (left or right) in contact with one wall of the maze the solver is guaranteed not to get lost and will reach a different exit if there is one; otherwise, the algorithm will return to the entrance having traversed every corridor next to that connected section of walls at least once (a depth-first in-order tree traversal algorithm).

Can you solve any of the mazes of the 1st activity using the second algorithm? You can use commands such as: move X units/cells/meters, turn left X degrees etc.

3rd Activity: Geo Space - Routes on maps

a. Plan and follow a route from one location to another.

- Choose from the Google Map as staring point your friend home and try to guide him with commands to come to your home. Can you summarize a basic set of commands, that can apply for urban roads?

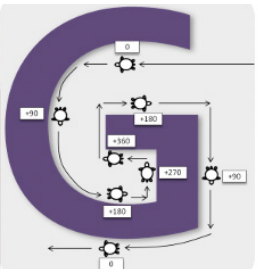
- b. Planet Mars: Where is the Perseverance Rover?
- At the interactive map of the Mars Perseverance Rover Location, you can see locations and traverse paths for the rover at the Jezero Crater and enjoy the journeys' overviews. The goal of the mission is to seek signs of ancient life and collect samples of rock and regolith for possible return to Earth.

- Can you design a simple path for the robot, on the map of the area, and then guide the robot to follow it, returning to its original position? You can use the same commands as before, e.g., move 100 m, turn 90 degrees etc.

4th Extended Activity: Engineering & Robotics - Maze constructions and robot movement

Teacher formulates groups of students supplying them with the available materials: scratch application, and/or robots and/or wooden pieces. The groups will be required to:

- Watch the video: Labyrinths for Thymio and create a maze according to the guidelines.
- Construct a robot with any kind of kit, with at least 3 wheels or use an existing robot (e.g., edison, thymio etc.), and write a program that simulates the solution given at the previous activity.
- Test their program-code for any shape of the maze.



Note: you can download the ready code from the "Core Code: infographic" https://www2.slideshare.net/EISTEAMProject/infographic-core-code or the Scratch "Core Code" application: https://scratch.mit.edu/projects/481599033

Reflection - Closing Activity (10-15 min)

Each student or groups of students, discuss the impressions on their missions and activities. They should express their positive or negative feelings on the progress of using algorithms (for mazes and routes) in their real life. The teacher should close the lesson by summarizing the final outcomes from objectives

5. EVALUATION / ASSESSMENT

Assessment Type: (what is measuring, assessing)

Skills (problem solving skills, teamwork skills, critical thinking); learning objectives; formative assessment; peer assessment;

Evaluation tools (instruments)

Presentations of the missions, tasks and mini projects

6. Real-world application

- Global application
- Real life situation projects
- Real-world facts and information research

7. Assignment

- Activity 1: individual task
- Activity 2: individual game playing
- Activity 3: team project
- Activity 4: team project

8. Extension

Trémaux's algorithm: "Efficient method to find the way out of a maze that requires drawing lines on the floor to mark a path, and is guaranteed to work for all mazes that have well-defined passages, but it is not guaranteed to find the shortest route".

Visualization (gif): "The large green dot shows the current position, the small blue dots show single marks on paths, and the red crosses show double marks. Once the exit is found, the route is traced through the singly-marked paths".

Authors: Y. Kotsanis, N. Vrionis

Lesson plan scenario 5

1. OVERVIEW

Lesson Topic Direct and inverse proportion. Their graphs.

Content Areas Functions

Duration of Lesson 2x 45 min

Target grades/ Age 7th grade/ 13-14

Brief description of the lesson

In the lesson:

1. an exercise about speed of movement is solved;
2. a research about relationships between distance, time and speed is planned and conducted as a pairwork.

2. LEARNING OBJECTIVES

General objectives

Student:

- can apply investigative learning methods to solve a problem;
- has an overview of languages of mathematics and robotics and can use them;
- develops the skill of reading and understanding a scientific text;
- gets an insight into connections between mathematics and technology;
- develops mathematical and technological literacy, creativity and a skill of systematic thinking.

Particular objectives

Student

- knows the following terms: speed, time, distance, direct proportion, inverse proportion, graph, straight line, hyperbola, branches of hyperbola;
- knows the formulas for calculating distance and speed;
- finds a suitable research question and hypothesis, plans experiments;
- measures, collects and analysis data, draws graphs based on collected data, accepts or rejects their hypothesis;
- constructs a robot and programs its movement according to the given task.

21st century skills gained

- critical thinking and problem solving;
- creativity;
- interaction and teamwork;
- managing and using information;
- using ICT.

3. METHODOLOGY

Teaching methods

- cooperative learning;
- peer teaching

Teaching techniques

- discussion;
- problem solving,

Prerequisites

Student

- knows units of distance, speed and time;
- can measure distance and time;
- can calculate and convert values of speed;
- can draw a graph;
- knows how to construct and program LegoSpike Prime robot;
- can read and follow given instructions.

Materials

- a video;
- a computer with internet connection, a projector;
- computers or tablets for students;
- one LegoSpike Prime set per pair of students;
- a stopwatch, a tape measure;
- writing and drawing tools, ruler.

Resources used by the teacher

- Google Classroom
- Google Docs
- Youtube
- Classroomscreen. com

Resources for the students

- Google Classroom
- Google Docs
- SPIKE™ LEGO® Education app

4. IMPLEMENTATION (organization of the lesson)

Introduction/ Motivation (15 min)

- Greeting, introduction of the topic and the aims of the lesson.
- Introductory video.
- Discussion based on the watched video. Students find examples from their daily lives.

Main Activity (65 min)

1. The teacher pairs up the students by using Classroomscreen.
2. The teacher introduces the activity and hands out worksheets, one worksheet per pair.
3. Students:

* familiarise themselves with the worksheet, if necessary, ask questions from the teacher about it.

* find suitable research questions and hypotheses.

*construct LegoSpike Prime robots. Additional guidance from the teacher might be needed.

*program robots to move. Additional guidance from the teacher might be needed.

*conduct the experiments, fill the table with findings, perform necessary calculations.

*draw graphs and analyse those.

*conclude their research, accept or reject their hypotheses.

*pairs introduce their research to peers.

Reflection/Closing Activity (10 min)

- The teacher makes their own conclusion about the findings of the research and asks the students to go to Mentimeter website which code is on the board.
- The students give feedback on the learning process and activities by using Mentimeter.
- The teacher shows the results on the board and concludes the lesson.

5. EVALUATION / ASSESSMENT

Assessment Type: (what is measuring, assessing)

- Conducting scientific research
- Problem solving skill
- Cooperation and interaction
- Critical thinking skill
- Creativity

Evaluation tools (instruments)

- Grading model

6. Real-world application

The students find illustrating examples of direct and inverse proportion from their daily lives.

7. Assignment

Homework:

Students in pairs put together a 1 to 2 minute video about experiments previously conducted by themselves.

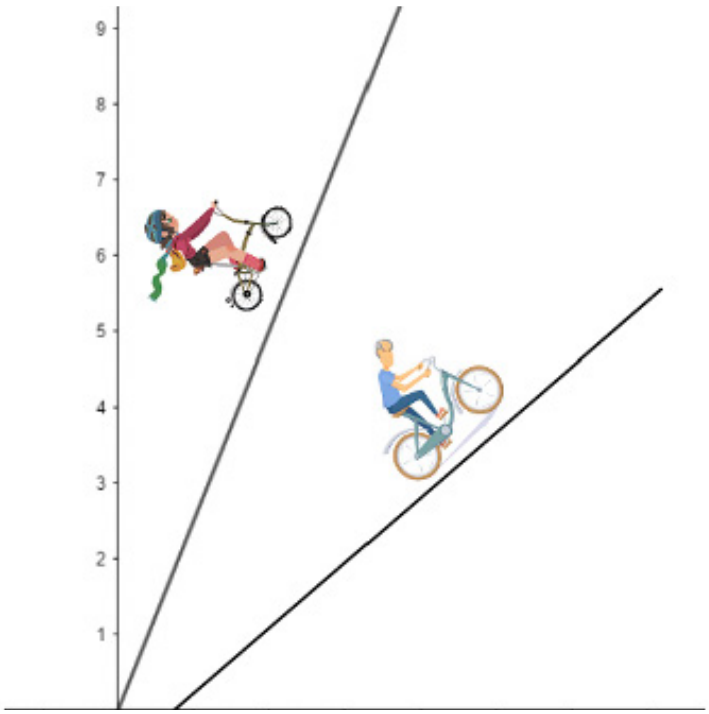
8. Extras

Student's worksheet

Author: Kairi Mustjatse

Lesson plan scenario 5 - Worksheet

Direct and inverse proportion and their graphs.



PROBLEM

Students of 7th grade go on a bike trip. The length of the trip is 30 kilometres. The students in the class have all different physical abilities. In general, those students could be divided into 4 different groups. Every subsequent group has students by a quarter weaker than in the previous group. What is the difference in speed between the first and the fourth group? Is it possible to calculate how many minutes the weakest group arrives at the destination later than the strongest group?

HYPOTHESES
Write down your hypotheses

You know that the distance is calculated by using the formula s = v*t,

where s is for **v is for** **and t is for**

You will use this formula for several times this lesson.

SOLUTION OF THE PROBLEM

Plan an experiment in order to solve the problem.

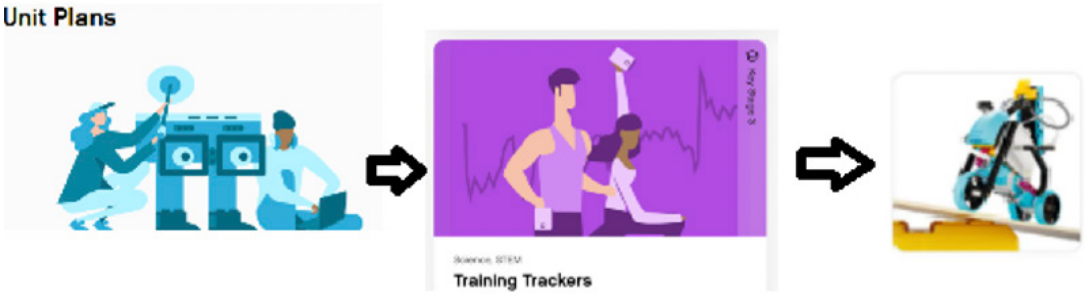
What is required for the experiment:

- LegoPrimeSpike set which you could use to construct a cyclist.
- A tablet with LegoPrimeSpike app. You will find instructions on constructing a cyclist from it.
- A programme
- A tape measure

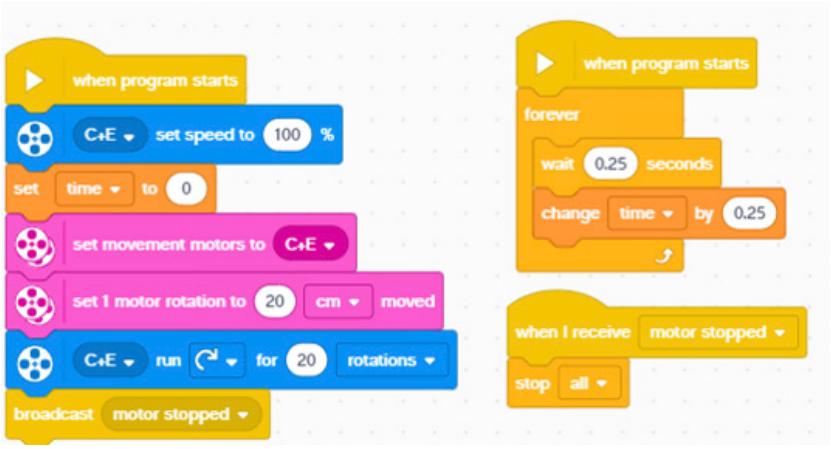
Write into this box a plan of your experiment

CONDUCTING THE EXPERIMENT

1) Construct a robot. Instructions are found in the app



2) Make your programme. Sample:



Look at the sample programme and answer the questions.

- How far should the robot move? .....
- Is the robot moving at maximum speed? .....
- In which direction is the robot moving? .....
- How accurately is the programme measuring time? .....

Upload the programme to the robot and conduct the experiment. Check your answers to the questions, correct them if necessary.
Measure, how far did the robot move and how much time did it take.

Distance moved .....

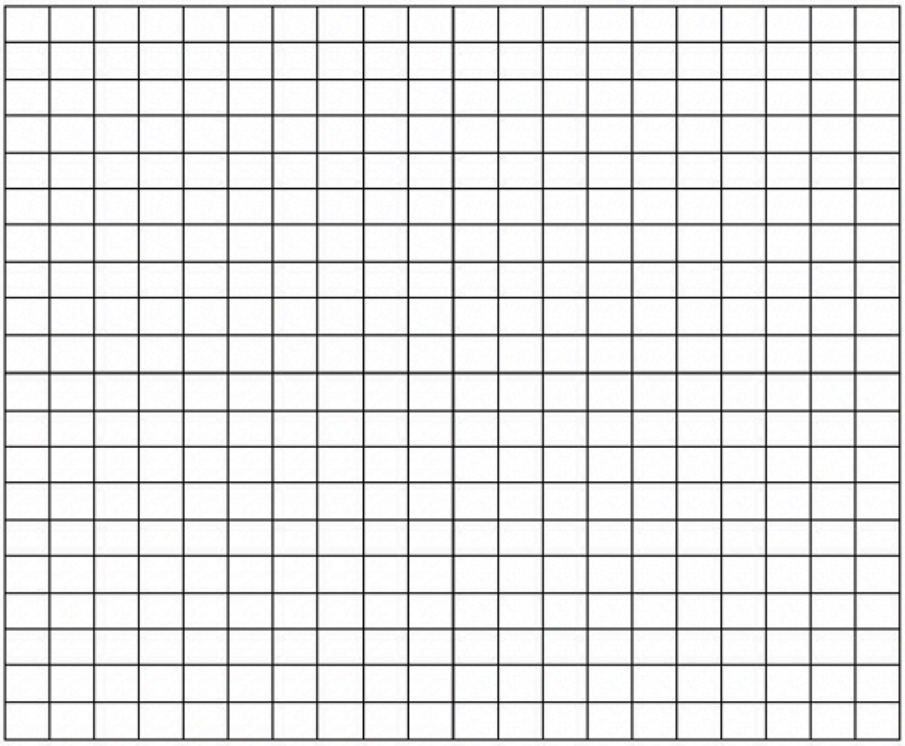
Time elapsed .....

3) Make necessary changes in the programme and conduct the experiments.

4) **Fulfill the table below with your findings.**

5) **Mark your findings on a coordinate system. Draw a graph or create one online here: https://www.onlinecharttool.com/**

The graph of uniform motion



6) Look at the graph. Describe

The formed geometric objects are

There are graphs of proportion.

The less it took time to move, the less is the graph and

7) Calculate the speeds of cyclists.

Write down which units of speed do you know.

I know

is a suitable unit for my robot-cyclist

The speed of the first robot-cyclist is

The speed of the second robot-cyclist is

The speed of the third robot-cyclist is

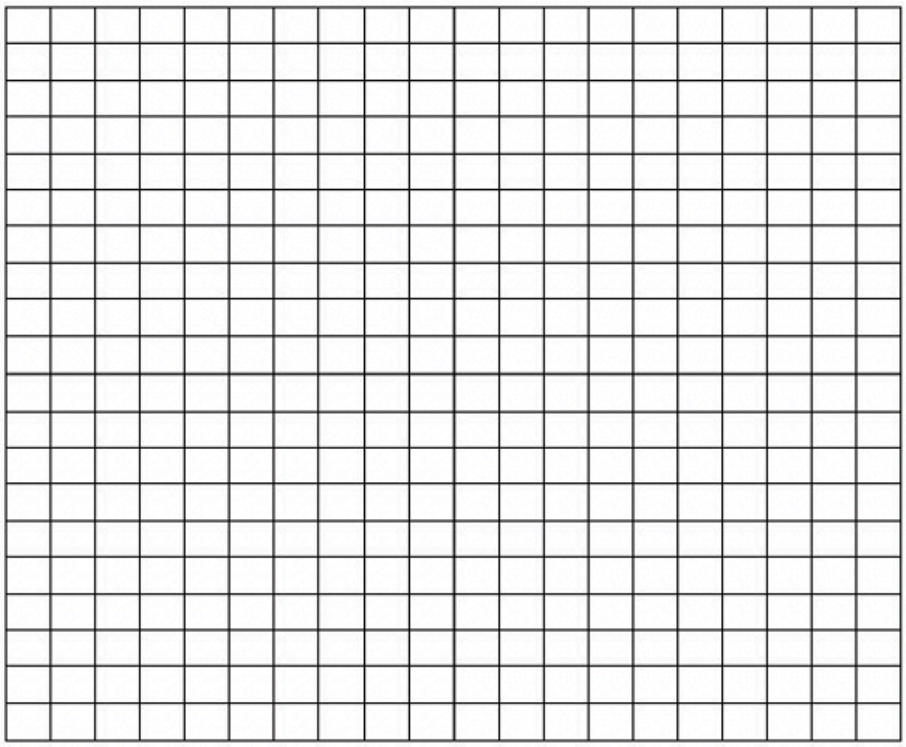
The speed of the fourth robot-cyclist is

8) Fill the table with the results of your calculations

Experiment	Time	Speed

What do you notice?

9) **Draw a graph or create one online here : https://www.onlinecharttool.com/**



Which proportion is it? Which geometric object did form?

Which proportion is it? Which geometric object did form?

How could these experiments help to answer the questions written at the beginning?

10) Perform the calculations according to your previously written plan and answer the questions found in the problem. Cross out wrong words in brackets .

The speed of the fourth group is times (bigger/smaller) than of the first group.

It seems that the fourth group reaches the destination minutes (earlier/later).

Lesson plan scenario 6

1. OVERVIEW

Lesson Topic Kinetic and potential energy

Content Areas Mechanical work and energy

Duration of Lesson 2x 45 min

Target grades/ Age 8 grade/ 14

Brief description of the lesson

In the lesson:

1. students are familiarised with kinetic and potential energy and the law of conservation of energy states.
2. students plan and conduct a scientific research on calculation of potential and kinetic energy as a teamwork.

2. LEARNING OBJECTIVES

General objectives

Student:

- knows the following terms: energy, potential energy, kinetic energy, the law of conservation of energy states;
- knows the formulas for calculating kinetic and potential energy;
- finds a suitable research question and hypothesis, plans experiments;
- measures, collects and analysis data, draws graphs based on collected data, accepts or rejects their hypothesis;
- constructs a robot and programs its movement according to the given task.

Particular objectives

Student

- knows the following terms: speed, time, distance, direct proportion, inverse proportion, graph, straight line, hyperbola, branches of hyperbola;
- knows the formulas for calculating distance and speed;
- finds a suitable research question and hypothesis, plans experiments;
- measures, collects and analysis data, draws graphs based on collected data, accepts or rejects their hypothesis;
- constructs a robot and programs its movement according to the given task.

21st century skills gained

- critical thinking and problem solving;
- creativity;
- interaction and teamwork;
- managing and using information;
- using IKT.

3. METHODOLOGY

Teaching methods

- video

- cooperative learning;
- peer teaching.

Teaching techniques

- discussion
- problem solving,

Prerequisites

Student:

- knows units of measurement of speed and energy, gravitation constant;
- can measure mass, distance, time and height;
- can calculate values of kinetic and potential energy;
- knows steps of conducting a scientific research;
- can draw a graph;
- knows how to construct and program LegoSpike Prime robot;
- can read and follow given instructions.

Materials

- video,
- computer with internet connection, projector;
- electronic and printed worksheet;
- computers or tablets for students;
- one LegoSpike Prime set per pair of students ;
- weight, stopwatch, tape measure, weights;
- writing and drawing tools, ruler.

Resources used by the teacher

- Google Classroom
- Google Docs
- Youtube
- Classroomscreen. com
- Mentimeter. com

Resources for the students

- Google Classroom
- Google Docs
- SPIKE™ LEGO® Education app
- Mentimeter

4. IMPLEMENTATION (organization of the lesson)

Introduction/ Motivation (15 min)

- Greeting, introduction of the topic and the aims of the lesson
- Introductory video;
- Discussion based on the watched video. Students find examples from their daily lives.
- The teacher makes a mindmap about the law of conservation of energy states on the board or

alternatively shows a presentation about the topic.

- cooperative learning;
- peer teaching.

Teaching techniques

- discussion
- problem solving,

Prerequisites

Student:

- knows units of measurement of speed and energy, gravitation constant;
- can measure mass, distance, time and height;
- can calculate values of kinetic and potential energy;
- knows steps of conducting a scientific research;
- can draw a graph;
- knows how to construct and program LegoSpike Prime robot;
- can read and follow given instructions.

Materials

- video,
- computer with internet connection, projector;
- electronic and printed worksheet;
- computers or tablets for students;
- one LegoSpike Prime set per pair of students ;
- weight, stopwatch, tape measure, weights;
- writing and drawing tools, ruler.

Resources used by the teacher

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Resources for the students

- Google Classroom
- Google Docs
- SPIKE™ LEGO® Education app
- Mentimeter

4. IMPLEMENTATION (organization of the lesson)

Introduction/ Motivation (15 min)

- Greeting, introduction of the topic and the aims of the lesson
- Introductory video;

- Discussion based on the watched video. Students find examples from their daily lives.
- The teacher makes a mindmap about the law of conservation of energy states on the board or alternatively shows a presentation about the topic.

Main Activity (65 min)

1. The teacher pairs up the students by using Classroomscreen;
2. The teacher introduces the activity and hand out worksheets, one worksheet per pair.
3. Students:

* familiarise themselves with the worksheet, if necessary, ask questions from teacher about it.
* find suitable research questions and hypotheses.
*construct LegoSpike Prime robots. Additional guidance from the teacher might be needed.
*program robots to move. Additional guidance from the teacher might be needed.
*conduct the experiments, fill the table with findings, perform necessary calculations.
* draw graphs and analyse those.
* conclude their research, accept or reject their hypotheses.
* pairs introduce their research to peers.

Reflection/Closing Activity (10 min)

- The teacher makes their own conclusion about the findings of the research and asks the students to go to Mentimeter website which code is on the board.
- The students give feedback on the learning process and activities by using Mentimeter.
- The teacher shows the results on the board and concludes the lesson.

5. EVALUATION / ASSESSMENT

Assessment Type:

(what is measuring, assessing)

- conducting scientific research;
- problem solving skill;
- cooperation and interaction;
- critical thinking skill;
- creativity.

Evaluation tools (instruments)

6. Real-world application

The students find examples of the law of conservation of energy states from their daily lives.

7. Assignment

Homework:

Students in pairs put together a 3-5 minute video about potential and kinetic energy.

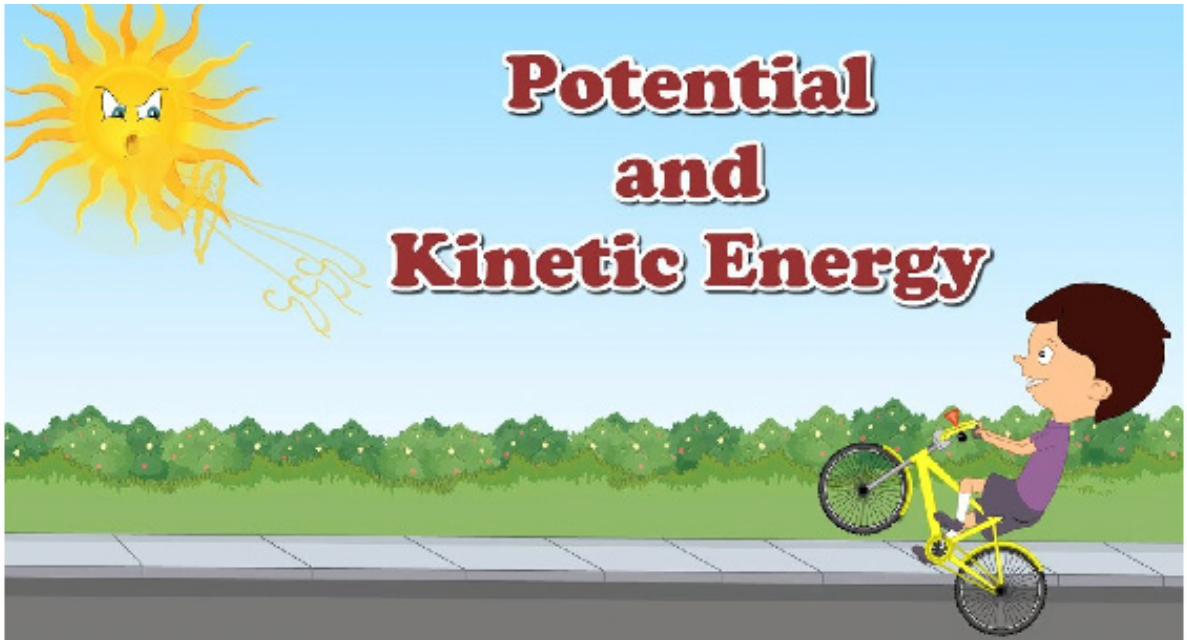
8. Extension

Author(s): Järvi Kimst

Lesson plan scenario 6 - RESEARCH WORKSHEET

Energy

Calculation of potential and kinetic energy



1. INTRODUCTION

The law of conservation of energy states - energy can neither be created nor destroyed; rather, it can only be transformed or transferred from one form to another.

Robot moves across the floor - it apparently has some energy because it is moving. Robot stops moving, let's lift it up and put it onto the desk - does it still have any energy left?

Research question

Figure out at least one research question related to the issue described above and write it down.

- The energy of a moving object is called **kinetic energy.**

$$E_k = \frac{mv^2}{2}$$

- The energy held by an object because of its position is called **potential energy.**

  Ep = m . g . h

Hypotheses

Write down your hypotheses:

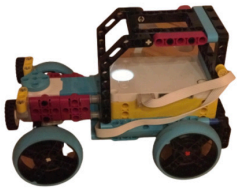
1) What are the amounts of potential and kinetic energy when the robot is moving across the floor?

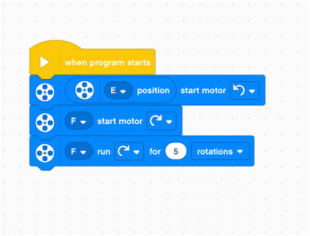
2) What are the amounts of potential and kinetic energy when the robot is not moving and is on your desk?

2. PLANNING THE EXPERIMENTS

What do you need for the experiments:

- LegoPrimeSpike set to build a moving robot instruction





- LegoPrimeSpike app to make a program so that the robot could move
- A weight to measure mass
- Tape measure to measure distance
- Stopwatch
- Weights to increase mass

Make a PLAN how you are going to check your hypotheses.

* CLUE: let the robot move on the floor with different weights. Then put the robot on the desk with the same weights.

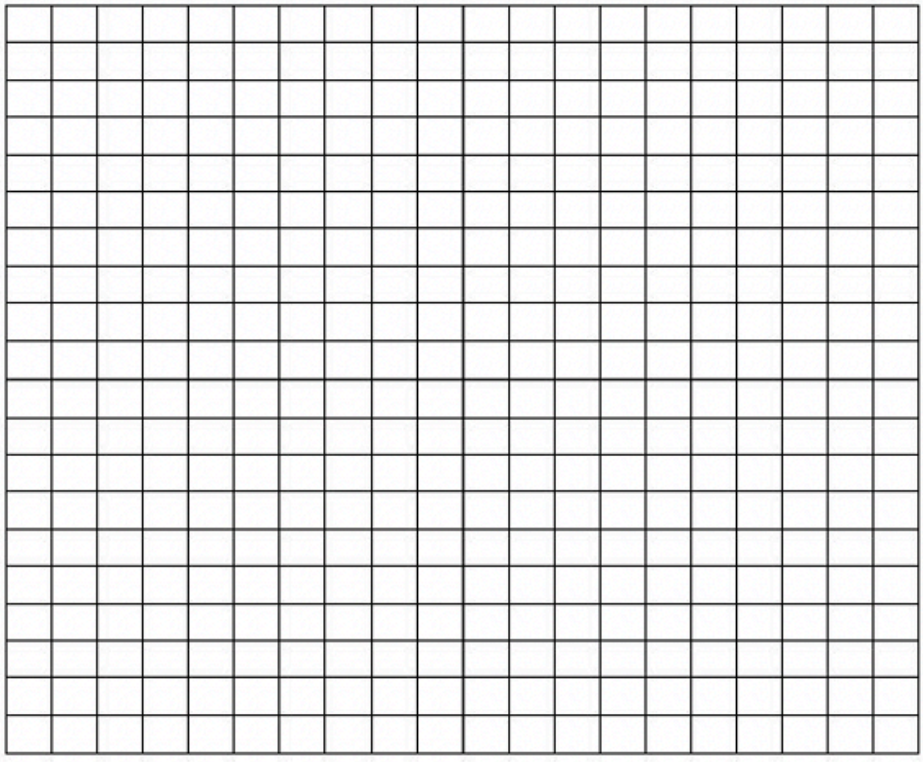
3. CONDUCTING THE EXPERIMENTS

1. Conduct your planned experiments.
2. Fill the table below with your findings.
3. Use the findings to calculate missing values.
4. According to the table draw a graph of potential energy and a graph of kinetic energy, x-axis shall be for the value of mass and y-axis for the values of kinetic or potential energy.

	Mass	Distance	Time	Speed	Height of the desk	Kinetic energy	Potential energy
Attempt 1							
Attempt 2							
Attempt 3							
Attempt 4							
Attempt 5							
Attempt 6							
Attempt 7							
Attempt 8							
Attempt 9							
Attempt 10							

Graph of kinetic energy

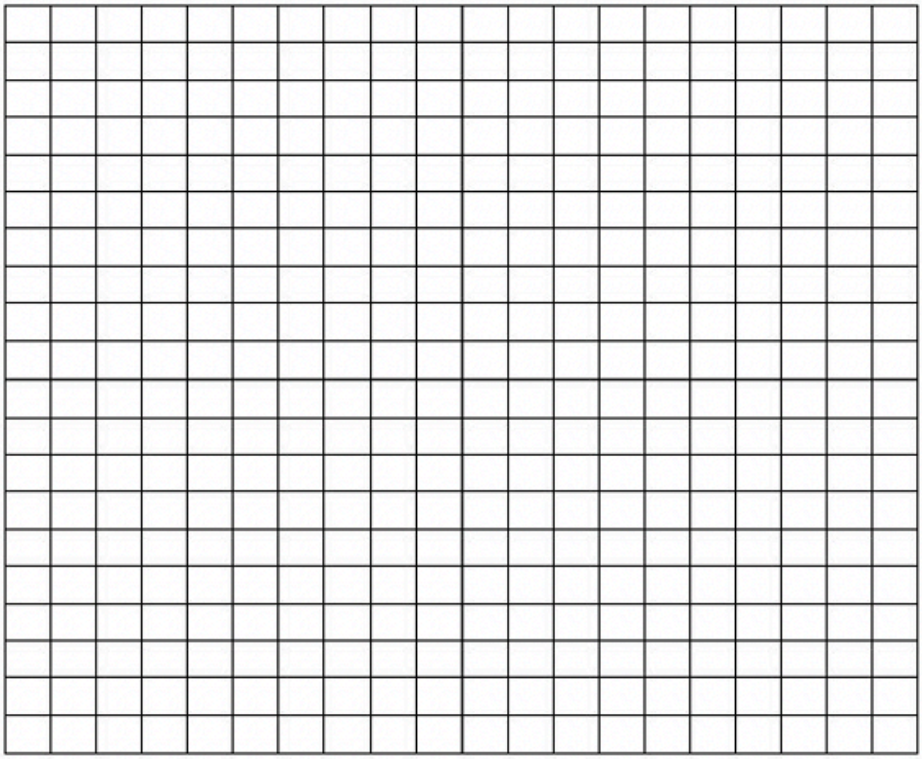
Draw a graph or create one online here: https://www.onlinecharttool.com/



What kind of graph is it? What do you conclude?

Graph of potential energy

Draw a graph or create one online here: https://www.onlinecharttool.com/



What kind of graph is it? What do you conclude?

4. Analysis

Accept or reject your hypothesis. If necessary, change your hypotheses.

***CLUE: how did the mass of the robot affect the values of kinetic and potential energy?**

Used resources:

https://sites.google.com/view/devbots/free-ebooks/hot-rod?fbclid=IwAR3C0bTm_SpXF0rEZ4vgXfDiQ5NOwkICE264M0O9vzlCIagrVku8gyVK49Y

Activity 1.7

Core messages for Motivation, Encouragement and Challenge

Partner responsible:
Enjoy Italy by Alesandro Gariano, Italy

Target group(s): educators, teachers, school authorities

How well prepared are young students to solve the problems that they will encounter in life beyond school, in order to fulfil their goals in work, as citizens and in further learning?

For some of life's challenges, they will need to draw on knowledge and skills learned in particular parts of the school curriculum – for example, to recognise and solve a mathematics related problem. Other problems will be less obviously linked to school knowledge, and will often require students to deal with unfamiliar situations by thinking flexibly and creatively.

Nowadays, the world has been changing rapidly, and the knowledge and skills acquired today are not foreseen to be sufficient while preparing our students for life.

It is emphasized that the 21st century skills, such as digital skills, critical thinking, cooperation, problem solving, innovative and analytical thinking, are more than required.

And STEM (science, technology, engineering and mathematics) education prepares all students for the challenges and opportunities in the 21st century economy.

The situation in the job market related to STEM shows that the employment rate of STEM skilled manpower is on the rise, despite the economic crisis, and is expected to keep on rising because of the growing demand. At the same time, a large number of STEM professionals are approaching retirement age. Around 7 million job openings are expected until 2025. The demand for STEM skills requires specialized training in both secondary and tertiary education[1] .

STEM learning is largely about designing creative solutions for real-world problems. When students learn within the context of authentic, problem-based STEM design, they can more clearly see the genuine impact of their learning.

Indeed, individual competencies in STEM subjects are getting more important for the occupations of the future which are based on high technology.

The era of the fast moving technology needs to be brought in the classroom, and more teachers need to be aware of the patterns that these students need, in order to capture their attention and make them acquire skills and competences.

But STEM subjects and skills are considered to be very challenging and not attractive to students, which is shown in the latest PISA (Programme for International Student Assessment) tests, which clearly show that students need different teaching and learning models.

The 2018 Pisa test results, announced in 2019, showed no progress in the EU students

1 Roungos G., Kalloniatis C., Matsinos Y. (2020). STEM Education in Europe & the PISA Test, Scientific Educational Journal "educ@tional circle"

performance in Mathematics and Science (European Commission, 2019). From 2000 to 2015, the advancement of STEM (Science, Technology, Engineering and Mathematics) Education has not been very encouraging. More specifically, although the goal is 15%, the 2015 results show that 22,2% of European students in Mathematics and 20,6 students in Science were not admitted to the third level of the Pisa test. And consequently, the United Nations SDG4 (Sustainable Development Goal 4) goal for quality education and sustainable development was not achieved [2].

Hence, the development of a solid, relevant scientific understanding of pre-university school students, as well as their preparation to face the challenges of an increasing technical world, requires an exposure to specific teaching practices, beliefs and attitudes. The teachers are key agents so they should promote high self-efficacy and learning outcomes expectancy, engage in challenging but also of impact practices, well aware of the 21st century skills and the future careers in the field[3] .

Therefore, we need to prepare all students for success after high school, regardless of whether they specialize in STEM fields or not.

Finally, innovative approaches are required in education. And innovative teachers too. Be one of them! Start innovating yourself. Now!

Target group(s): policy makers at regional/ State/EU level, regional/State boards of education and other education agencies

STEM education has become one of the main priorities at European level closely connected to countries global score related to competitiveness. The World Competitiveness Report 2015-2016[4] , which provides an overview of competitiveness in 140 countries, reveals that education reform must be a key focus of the agenda of governments and policymakers to increase the competitiveness of the economy today, an economy based on innovation, technology and entrepreneurship[5].

The situation in the job market related to STEM shows that the employment rate of STEM skilled manpower is on the rise, despite the economic crisis, and is expected to keep on rising because of the growing demand. At the same time, a large number of STEM professionals are approaching retirement age. Around 7 million job openings are expected until 2025. The demand for STEM skills requires specialized training in both secondary and tertiary education[6].

But STEM subjects and skills are considered to be very challenging and not attractive to students, which is shown in the latest PISA (Programme for International Student Assessment) tests, which clearly show that students need different teaching and learning models.

The 2018 Pisa test results, announced in 2019, showed no progress in the EU students performance in Mathematics and Science (European Commission, 2019). From 2000 to 2015, the advancement of STEM (Science, Technology, Engineering and Mathematics) Education has not been very encouraging. More specifically, although the goal is 15%, the 2015 results show that 22,2% of European students in Mathematics and 20,6 students in Science were not admitted to the third level of the Pisa test. And consequently, the United Nations SDG4 (Sustainable Development Goal 4) goal for quality education and sustainable development was not achieved[7].

Therefore we embrace the following five actions to advance effective STEM education, as indicated by the Scientix Observatory report of December 2018 on the STEM Education Practices in Europe[8]:

- Supporting innovative STEM teaching practices and networks based on Inquiry based Science education (IBSE), and other student-centred pedagogies: there is still a lack of confidence, at the level of STEM teachers, in approaching more innovative pedagogies;
- Offering relevant professional development

2 Idem
3 A. Popovici, O. Istrate, C. Mironov (2019). Teachers' Perspective on the Premises and Priorities of STEM Education, European Schoolnet
4 Schwab, K. (2015). The Global Competitiveness Report 2015-2016, World Economic Forum
5 A. Popovici, O. Istrate, C. Mironov (2019). Teachers' Perspective on the Premises and Priorities of STEM Education, European Schoolnet
6 Roungos G., Kalloniatis C., Matsinos Y. (2020). STEM Education in Europe & the PISA Test, Scientific Educational Journal "educ@tional circle"
7 Idem
8 Nistor, A., Gras-Velazquez, A., Billon, N. & Mihai, G. (2018). Science, Technology, Engineering and Mathematics Education Practices in Europe. Scientix Observatory report - December 2018, European Schoolnet

opportunities for STEM teachers and strengthening school-industry collaboration: there is a clear need to support the development and dissemination of relevant STEM training programmes which encourage teachers to build their subject and pedagogical knowledge as well as their confidence in using new technologies in the classroom;

- Innovating the STEM education curriculum and assessment: an important factor is the way the curriculum is written and expected to be taught. Assessment policies that give sufficient weight to formative evaluation methods are needed so as not to inhibit the use of innovative pedagogies in the final years of education;
- Supporting the development and implementation of whole-school STEM oriented strategies: developing a clear STEM strategy at the school level to promote and support innovative STEM teaching can play an essential role in coordinating efforts to improve the quality of STEM teaching and to ensure that STEM teachers benefit from the appropriate support to improve their practice;
- Strengthening trans-disciplinary collaboration to encourage the uptake of integrative STEM teaching: consider strengthening teachers' collaboration and encouraging the exchange of good practices across disciplines to ensure that the conditions are met for a meaningful integrative STEM education in classrooms.

We can innovate, we have to. We can succeed, we have to. For a better present and for a brighter future of our new generations. And for us all!

Erasmus+

Project: STEM Labyrinth as a method for increasing the level of knowledge through problem solving
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STEM LABYRINTH

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