STEAM IT

AN INTERDISCIPLINARY STEM APPROACH

STE(A)M IT INTEGRATED LEARNING SCENARIO

Together, we can make a difference

Natural Sciences, Arts, Physics

Mathematics, Language

USE IT IN YOUR CLASSROOM

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INTRODUCTION

In order to inspire students, see the added value of STEM subjects and careers, contributing the same way in tacking unfavourable perceptions and the overall lack of interest in Science, there is a need to reconsider the way STEM subjects are taught. For this purpose, there is a need for an integrated way of teaching. More specifically, there is a need to combine Science classes with other disciplines, ensuring that the integrated STE(A)M education will contextualize STEM teaching is such a way that it becomes more attractive for every student. Right now, there is no integrated STE(A)M education framework in Europe that will further enhance coherence in STEM education. It is essential to bring together partners from different countries, already working in STE(A)M education, policy, pedagogical innovation and professional development of teachers, educators and school leaders, and engage them in discussions, planning, implementing and the review of new practices. This will ensure that the topic is given new and more intense attention within each country. Therefore, the STE(A)M IT project will lead the way in the creation and testing of the 1st Integrated STE(A)M framework, aiming to strengthen the coherence in STEM education by defining collectively with MoEs and STEM teachers the integrated STE(A)M education framework. The focus group teachers that will create interdisciplinary and innovative teaching and learning scenarios, will be used to test the proposed framework of reference for integrated STE(A)M education.

The creation and implementation of the aforementioned framework is particularly important for students who do not link STEM subjects and their use with their everyday life, but most importantly with their future career paths. The teaching of each STEM subject individually often prevents students from linking those subjects, consequently missing out on a cohesive educational opportunity that might largely affect their study path choice and eventually career.

It is additionally important for teachers of Primary and Secondary schools to work together and fully exploit the benefits of the in-between them collaboration, while contributing to the creation of innovative and cross-disciplinary approaches to STE(A)M teaching in education, each adding their own insight, expertise and knowledge. This collaboration and continuous feedback aim to provide an opportunity for reflection and support a steady and much necessary change in formal education but also career consultancy. This way, schools will assume the additional role of mentorship supporting their students collectively.

A STE(A)M IT Integrated lesson plan is a teacher's detailed description of the course of instruction or "learning trajectory" for a lesson, a guide and a document that will be

continuously improved and updated. Each lesson needs to combine three subjects, two of the subjects must be STEM and the third subject can be either STEM or non-STEM. is about designing educational activities that facilitate deep learning to enhance 21st century skills such as critical thinking, collaboration, communication and creativity and divergent thinking. Designing a path based on methodologies such as Problem, Project and Challenged Based learning allow to incorporate problem-solving, inquiry and design based learning into the teaching activity taking care of real challenges in an authentic context, that of our world.

With this in mind, an integrated STEM approach will develop capable citizens who personally and professionally make informed decisions in their daily lives and have the power to follow STEM careers and guide innovation at any age.

Title

Together we can make a difference

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Summary

We live in a world that is constantly changing, and every day it seems to change more quickly. Humankind is facing unprecedented revolutions. How can we prepare our students for a world of transformations? What should we teach our students today that will help them live and flourish in 2030 or set the basis for the 22nd century? What kind of skills will they need to get a job, understand what is happening around them? Since nobody knows what the world will look like in 2030, not to mention 2100, we don't know the answer to these questions. People have never been able to predict the future with accuracy. But children are the future of the world and through this scenario students are asked to anticipate any potential changes they think might be coming and find solutions on how to better preserve the environment, how we can decrease the levels of pollution (atmospheric, water, ocean), and have more green space or better air quality and how can they save energy to help ecosystems.

Licenses

Subject (s)

STEM subjects:

1. Natural science
2. Mathematics
3. Physics

Non – STEM subjects:

1. Language
2. Art

Real- life questions

Through this learning scenario students will be introduced with topics that will originate them to think about the future in about 20 -30 years from now and help them give answers to some real-life questions like:

- What does the future look like for people living on Earth if we continue to treat our planet the way that we do?
- How will climate changes and energy we consume have an impact on environment, ecosystem?
- How does a polluted environment affect our health?
- How Earth could be a better place and what are some wrongdoings we need to correct?
- What conclusions can we reach after monitoring the data from our energy consumption?

Aims of the lesson

Students will:

- develop awareness of the threats to our environment
- develop environmentally friendly behaviour
- develop the skills and habits that will help Earth stay beautiful and clean
- learn through the creative processes of designing, creating, inquiring, and exploring
- improve their communication skills and collaborative learning
- be able to give solutions how can we help the future of our environment, planet Earth.

Connection to STEM careers

- Environmental scientists - eliminate sources of pollutants or hazards affecting the environment (activities in 3rd lesson - Natural science)
- Biologist or biology teacher (activities in 3rd lesson - Natural science)

- Environmental physicists - careers in remote sensing, atmospheric climate modelling, pollution control, energy conservation, renewable energy (activities in 4th lesson Physics and 5th - Mathematics)
- Geographer – explains how the natural environment contributes to human society and how human society affects the natural environment (activities in 3rd lesson - Natural science and4th lesson Physics)

Age of students

8 – 9

Time

Preparation time:

- 3 hours to prepare activities in each subject with colleagues

Teaching time:

- Brainstorming and discussion – 45 min
- STEM Subject 1: Natural Sciences – 200 min
- STEM Subject 2: Physics – 90 min
- STEM Subject 3: Mathematics – 45 min
- Non-STEM subject 1: Language – 45 min
- Non-STEM subject 2: Art – 90 min

Teaching resources (material & online tools)

Materials:

- Papers
- Pencils
- Notebook
- Cardboard
- Plastic box
- Whiteboard/smartboard
- Projector
- Scissors, glue
- Mobile phone/tablet/computer
- Camera
- Internet

Online tools:

- Microsoft Office 365 (Word, PowerPoint, OneDrive, Forms)
- Apps for quiz (Google Forms, Kahoot, Plickers, Quizlet)
- Google translate tool https://translate.google.hr/

Resources:

Videos in Croatian language:

- https://www.youtube.com/watch?v=jBb2kkSmBGQ (energy and climate change - effect on our Planet)

- https://www.youtube.com/watch?v=0NtoL5mfizc

Videos in English language:

- "Care for environment": https://www.youtube.com/watch?v=V0lQ3ljjl40
- "Save our planet": https://www.youtube.com/watch?v=Kqc5RvWIPRE

21st century skills

This lesson plan will enhance among the students the following skills, defined as 21st century skills:

- **Learning skills**
  - **Critical thinking**: Students will be asked to reflect on everyday issues and figure out solutions for every given problem during the discussion.
  - **Problem solving**: Students will define problems that affect environmental changes, develop, and deliver a solution.
- **Technology skills**
  - **Information literacy**: Students will receive relevant information about climate change, pollution energy that will help them form opinions and answers to real-life questions.
- **Life and career skills**
  - **Initiative**: Students will take initiative to help their community
  - **Social skills**: Students will develop positive attitudes, learn how to interact with one another and value each other's opinions.
  - **Creativity**: Students will exercise their creative thinking skills, taking information from their analysis of a problem and the conclusions from their critique, and use them to create useful ideas and problem solutions
  - **Communication**: Students will engage in constructive dialogue and listen to each other's suggestions and opinions. In addition, through the Arts class they will have the chance to produce materials for visual communication.
  - **Collaboration**: Students in class will collaborate with each other to solve problems and bring change in their local community and nature around them.
  - **Productivity and accountability**: Students will plan and manage time for doing all activities effectively, participate actively and collaborate effectively.
  - **Responsibility**: Students will be asked to suggest applicable and realistic solutions to follow.

Lesson Plan

The implementation of integrated STEM teaching and learning is facilitated by the use of specific pedagogical approaches (PBL, IBL, etc). In order to facilitate the research done by the

teachers and the design of activities by teachers, a selection of such approaches is presented in Annex 1. Maintaining Annex 1 in the Learning Scenario and citing where necessary is mandatory.

Name of activity	Procedure	Time
1st Lesson		
Brainstorming and discussion	Teachers introduce the topic of the learning scenario which is environmental awareness. They start brainstorming around the main problematic ''*Earth does not belong to us. We belong to the Earth*''.	45'
Discussion and preparation for the next lesson	Students with teacher guidance start discussing about what the environment is, what kind of environment is healthy to live in, who and what pollutes our planet. Is the technology we have today making our lives better or is it harmful? What are the renewable energy sources and how can we use them? Are there solutions to how Earth could be a better place and what are some wrongdoings we need to correct to make our environment better, heathier?	
2nd Lesson		
Non-STEM Subject 1	**Language**	45'
Assignment in class	*Students' assignment:* *Consider what your country will be like in the future, for example 30 years from now. Think about pollution, environment, climate change, energy, education, careers, and jobs.* Each student has to write an essay outlining their thoughts, ideas and explaining how this topics will have an impact on the future of their local community or city they live in, the environment around them and give their thoughts on	

Name of activity	Procedure	Time
	potential solutions of how Earth could be a better place and what are some wrongdoings we need to correct.	
Learning products	Students make a class book "What the future holds - our stories"	
3rd Lesson		
STEM Subject 1	**Natural science**	200'
Discussion in class	Students and their teacher start a discussion based on the following problem/question: *We have a white handkerchief, what happens if we start the car and put the handkerchief on the car exhaust pipe?* (Students have to come to the conclusion that cars, buses and other road traffic pollute the environment.) Teachers discuss with students about the following topics: 1. *How does a polluted environment affect our health?* 2. *Who must be responsible for the environment?* Following, students watch the below videos: • "Care for environment": https://www.youtube.com/watch?v=V0lQ3Ijjl40 • "Save our planet": https://www.youtube.com/watch?v=Kqc5RvWIPRE After watching the videos, students receive a self-assessment sheet to see how much they take care of the environment themselves. After talking to students about environment and nature, students are making one poster with their eco-messages and one poster with a solutions how to save the future of environment of their city and World in general and make a better future for people (example: turn off electrical	

Name of activity	Procedure	Time
	appliances when not in use; replace plastic bags with linen; sort the waste and dispose of it in the containers provided; if you have the option buy organic, chemical-free foods or hygiene products that are labelled as natural ingredients etc. <u>Assignment in the school yard:</u> Students with help of a teacher plant in a school yard different sorts of plants to show one of the ways to reduce the ecological footprint without pesticides and fertilizers.	
Learning products	• The poster students created with suggestions on how to protect the environment • School garden	
4th Lesson		
STEM Subject 2	**Physics**	90’
STEM Subject 3/non-STEM subject Watching videos in class, discussion, group work	• Students watch a video about energy, renewable energy and energy sources: https://www.youtube.com/watch?v=jBb2kkSmBGQ • Teacher and students discuss about energy and fuel (what types of energy they know, renewable non-renewable energy sources, where does energy comes from, types of fuel and which is the best for environment and why, fossil fuels and greenhouse effect). • Students divided in groups receive a short text about one renewable energy (example: group 1 – Solar energy, group 2 – Water energy…). Groups will read through the text on their energy source, then write on sticky notes (one per note) renewable energy solutions for environment, country where they live and their future. Each group will take a turn	

Name of activity	Procedure	Time
	explaining their renewable energy source to other groups including advantages and disadvantages and stick them on a class table on the board in the appropriate row/column. The table will not only serve as a reference for students, but also as an assessment method evaluating common thinking. • Students work in pairs and write on post-it notes 2 suggestions on how we can reduce energy. They place them on the whiteboard/writing panel and then together with teacher make a *Energy action plan: 10 easy ways to save energy* (Annex 2) <u>Assignment for homework:</u> Students make a windmill and create a short video explaining energy of the wind.	
Learning products	Energy action plan	
5th Lesson		
STEM Subject 3	**Mathematics**	45’
	• Before coming to class students collect from their parents data: the amount of money their parents have payed to cover electric bills for past few months (3 or 4). At home, students determine the current state of the number of devices / units and the electricity consumption in the past few months. • Students create twos tables containing the following data: Table 1: Determine the number of devices and the consumption of electricity in the past few months (list of household appliances that use electricity; Calculate the frequency a device uses electricity: a) constantly b) occasionally; Consumption of electricity by months in kW/h; Price of electricity consumed in each given month)	

Name of activity	Procedure	Time
	• Table 2: One year energy savings forecast (Indicate what activities I and my family can do to help save electricity in the household; Predict which household appliances might use less electricity from Table 1.; Monthly electricity consumption in kWh - student can read the meter with the help of an adult to determine the kWh difference per month; Price of electricity consumed). Students may have the Tables in their notebooks and the teacher can monitor the student's notes at any time. Students discuss and analyse conclusions by the condition found in Table 1 with a later reading of the energy consumed. The conclusion should be compared with the prediction. If more kWh is consumed than expected, the possible reasons should be listed. If the prediction and the actual state of affairs coincide, students can draw the conclusion of the research.	
Learning products	Notes and research outcome	
6th Lesson		
Non-STEM Subject 1	**Art**	90’
Drawing and preparing for the class’ exhibition	Students are given pictures of very crowded cities and non-urban places with significant industrial activity. Teacher and students discuss about question how high the danger is to destroy environment outside cities as well. • Students draw 2 pictures: 1. Their city or country in 30 years depicting how it will look like if people don’t take care of it, if they won’t be environmentally conscious etc.	

Name of activity	Procedure	Time
	2. Their city or country in 30 years if people will take care of it, if they will be environmentally conscious, if they will follow energy plans etc. Students make a class exhibition. • *Visual storytelling:* With group artwork, students draw and wrote messages on a big role of paper about what kind of planet Earth they want that will be presented on the panel or wall in school <u>Extra activity (if time allows)</u> • Time capsule for future generations: students put in a box one drawing from 1. assignment, one toy and a letter in which students write how their local community, city or country is looking today, what they play with, how their education looks alike, their hobbies etc. Students place time capsule in the ground in school yard.	
Learning products	Exhibition of students work, visual story created on panel, windmills	

Assessment

The assessment will be carried with the use of questionnaire (online or on paper) using online tools (Google Forms, Kahoot, Plickers, Quizlet).

Initial assessment

During the first, third and fourth lesson initial information about environment, energy and fuels will be gathered through discussion.

Formative evaluation

During the first, third and fourth lesson formative assessment will take place in the form of a survey, or quizzes with the purpose of gathering information if all learning outcomes are achieved.

Final assessment

The final assessment will be carried out by students through final class presentation to school staff and parents and local community.

Student feedback

Each student will fill a satisfaction survey questionnaire and will be interviewed about LS.

Teacher feedback

When it comes to the teaching outcomes, as a team of teachers this kind of teaching helped us collaborate more and more efficiently, and explore new styles of teaching or activities so we can help our students in cross-disciplinary thinking.

We would say and encourage other educators to try integrated STEM learning scenarios because it supports systematic problem-solving and the development of critical analysis skills, helping students increase their STEM knowledge, while engaging and developing cross-disciplinary thinking.

When it comes to the adaptations of the learning scenario as initially planned, we had implemented some because not all of students were in school due to the pandemic situation and the online teaching that took place. During the 5th lesson dedicated to Mathematics we didn't implement them the way we had planned because it was required that those activities take place in class, while our mathematics curriculum was adapted in order to be compatible with remote teaching and online schooling in May. The time we allocated was enough because we didn't implement all activities, but we had to add extra time to prepare the school garden. All team members implemented the designed activities despite the common challenges.

When it comes to the choice of activities, we added some hands-on activities like the creation of wind wills and a school garden. In the subject of Natural science, we removed a writing activity.

Lastly, parents contributed to the learning scenario implementation supporting students. In some occasions, they thought that an alternative method is being implemented, and expressed their concern over the time will they would have to spend introducing their children to unfamiliar topics. But overall students and parents provided positive feedback about this different, informative approach and students' involvement with STEM subjects.

Annexes

A thorough and complete list of all the materials used will be asked from all teachers. Those materials will be cited as Annexes and they can be further cited in the learning scenario.

Annex 1

PEDAGOGICAL TRENDS IN EDUCATION

Disclaimer: Information presented in this document has been previously partially published in the Scientix Newsletter "Pedagogical trends in education", May 2019: http://files.eun.org/scientix/scx3/newsletter/Scientix-Newsletter-May-19.pdf

Inquiry-based science education

IBSE adopts John Dewey's principle that education begins with curiosity (Savery, 2006), and makes students go through all the steps of scientific research: ask a question, develop a hypothesis, plan how to test this hypothesis, collect data, analyse the results and share it with peers (Pedaste et al. 2015). IBSE is ideal for science education, because it makes teaching more hands-on, and is perfect to learn how scientific research works. Students learn how to formulate questions answerable through experimentation. The teacher has both a facilitator role and an instructor role, making it an in-between method compared to full facilitation in problem-based, and instruction in project-based learning. However, the approach can be gradually made student-directed; students can start an IBSE project with a question provided by the teacher, and then can come up with their own questions to transfer what they learned for deeper learning.

IBSE does not only tap into creativity, problem-solving, and critical and analytical thinking. It also sets the stage for learning about how to collect and interpret data (become science and data-literate), and how to do this ethically and reliably. All these are skills of the 21st century, where data is abundantly available in every part of life.

As mentioned in the recent European Schoolnet publication, while inquiry-based science education (IBSE) has been already around in STEM education for decades, there is still much room for improvement in teachers' development and continued dissemination of innovative pedagogical approaches. To highlight the impact of IBSE, its challenges, and the initiatives

addressing these, we published the "Teacher Training and IBSE Practice in Europe, A European Schoolnet overview".

Research shows that IBSE results in greater interest in Science, and motivation for STEM careers. Another important observation from the publication is that the benefits of IBSE are long-term and maintained, in contrast to the short-term acquisitions of traditional pedagogies that also come with less inclusion of both genders, and less interest in STEM.

One challenge is teacher support: teachers report that they receive little support in implementing IBSE in their classroom. Another challenge to IBSE is standard assessment: PISA tests, as well as end-of-secondary-education exams, are still more focused on recall and repeated-drill exercises, deterring the use of more diverse pedagogies. In order to better integrate inquiry-based methods in school curricula, standardized tests also need to evolve along with traditional pedagogies.

Problem, project and challenge-based learning

Problem-based learning (PBL) is a student-centred multi-disciplinary method that was initially adopted in medical education as a means to put multiple topics in context (Newman, 2003) PBL aims to make students good problem-solvers in the real world: for instance, to put knowledge from multiple disciplines into use, and be able to work with others productively. After all, real-world problems are hardly ever solvable by one single discipline and one single person.

A PBL activity consists of working on an open-ended, even ill-defined question, with no solution provided by the teacher. Students need to work collaboratively and devise a solution to the problem by themselves. The key component is that it is student-centred; students are more motivated when they are responsible for the solution to the problem, and when the whole process rests with them (Savery, 2006). Decades of research has established that although students who went through PBL do not necessarily score better on standardized exams, they are definitely better problem-solvers (Strobel & van Barneveld, 2009).

Project-based learning also involves collaborative learning and finding a solution to a problem. However, the process and the end product are more specified from the beginning. Students work on a project for an extended period of time, a project that will produce a solution to a complex question or solve a complicated problem. The role of the teacher is more active here because multiple obstacles are typically encountered in the production of something like a rocket, or a space habitat, and these obstacles mark the moments for the teacher to instruct specific topics.

Finally, with **challenge-based learning (CBL)** (Johnson et al. 2009), students are again asked to develop a solution to a problem. However, they are only provided with a "big idea", a societal problem that they need to address with a challenge of their choosing (e.g. disinterest in mathematics, low upturn in elections). While the use of technology can be considered optional in other trends, technology needs to be incorporated in every step in CBL. Similar to project-based learning, there is an end product, although this product is determined in the process, not at the beginning. The focus is on the use of ICT in the collection of data and sharing the results.

Design thinking

If IBSE recreates scientific methodology in the classroom, **design thinking (DT)** does the same for design and prototype production. DT helps students develop the skill to identify problems and needs in the society, and entrepreneurship. DT can be implemented within problem or project-based learning; the difference is that the problem is identified by students, and the end product is a prototype to solve the problem. The product is tested and refined in multiple iterations. Students go through a cycle of steps: (1) empathize; (2) define; (3) ideate; (4) prototype; (5) test.

Blended-learning and the flipped classroom

In a classroom where all students are facing the instructor, each moment there will be students drifting from the topic, even if for thinking deeper about a specific point in the lecture. It is challenging to have the undivided attention of the whole classroom because each student has a different way of learning and a different pace. With online content, students can learn the material at home at their own pace. In turn, the teacher can use the classroom to engage students in debates, projects and group assignments. Blended-learning and flipped classroom are instructional strategies that help students learn in their own pace, and deepen their learning with making the most of classroom hours. Although these concepts are used interchangeably, they are slightly different: while blended learning complements online learning with class instruction and support, the flipped classroom requires students to learn the material before coming to class and do assignments and projects during class hours.

Content and Language Integrated Learning (CLIL)

Content and language integrated learning (CLIL) is a well-positioned pedagogical approach that emphasises on the integration of foreign language and thematic content within the context of all school subjects. CLIL is a pedagogical approach that allows to teachers and

students use a foreign language as the medium of instruction in non-linguistic subjects, allowing this way the practice and improvement of both the second language and the immersion to subjects that may vary from science subjects to humanities. According to Cenoz et al. (2013) "*the European Commission and the Council of Europe have funded many initiatives in support of CLIL because it responded to a need in Europe for enhancing second-language (L2) education and bilingualism that was well-received*" and research further supports that CLIL is applied successfully in task-based pedagogies. In addition, when it comes specifically to the application of CLIL in the science classroom there are specific advantages including enabling learners to learn a school subject that exists in their curriculum using the respective second language they are learning, provide authentic learning settings while using the resources available at their school and support learners' cognitive skills by equally supporting language practice and the teaching of science context.

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Annex 2

STEM Subject 2 - Physics – Energy action plan - Example

Energy action plan – 10 ways to save energy	
1	Turn off the lights when you leave the room
2	Turn off computer, tv and other devices when you are not using them!
3	Use natural light and heating
4	Reduce the temperature in the house by a few degrees
5	Close the doors to the windows in winter when the heating is on
6	Travel to school with bike not with a car
7	
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