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OTA

Online Teaching Advancement

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OTA - Online Teaching Advancement – Science through Art

OTA Learning Methodology

compiled by

Izobraževalni center Geoss d.o.o. (SI)

with

Innovade (CY), CESIE (IT), Narodna galerija (SI), Osnovna šola Litija (SI), Heureka – the Finnish Science Centre (FI)

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CHAPTER 1: OTA METHODOLOGY

1 INTRODUCTION

When developing OTA methodology the first step was a thorough research on some educational approaches, which are relevant when teaching science subjects and combining them with art – or as OTA refers – teaching/learning them **through** art.

Next step was implementation of those approaches in OTA methodology to form a solid base on what this project wants to achieve.

Research gave a special attention on two pedagogical concepts - **three stage model** approach and STEAM approach.

OTA project is coming out of the situation when a great deal of learning has to be done remotely and for a longer period. Therefore – the activities coming from OTA Methodology are flexible. Basis for their implementation is online, but should be easily adoptable also in live sessions.

OTA methodology is coming out of the three stage model, which emphasises the importance of science in society; interdisciplinary STEAM approach; specifics of online teaching and learning; resource-based learning; experiential learning; creative problem solving; small-group working and teacher-led large groups. Using OTA methodology is also implementing elements of informal learning overall staying in line with the curriculum.

The objective of OTA methodology is to provide positive learning experience for pupils, increase their intrinsic interest in science, establish their understanding that science is a part of real life and it is important for the society, for the wellbeing of the society, for the environment and preserving it. Using art expressions to achieve these objectives is a benefit not only for pupils but for the whole spectrum of the curriculum, because it will increase not only science education but also pupils' appreciation of art expressions and will enhance their ability to connect science with an environment, which is outside of their (virtual) classrooms.

2 CORE PRINCIPLES OF OTA METHODOLOGY

The core principles of OTA Methodology are based on the STEAM method in educational settings. In IO1 the online survey among teachers of science subjects was made and also focus groups in each of the participating countries were conducted. Analysis of the national reports shows that the majority of teachers are not familiar with the word STEAM, though they are using this methodology within their classes almost autonomously.

Another element noted by the analysis is that teachers have realised how indispensable it is to make students more involved.

Despite the stress and lack of time, teachers expressed in the four partner countries, there was a strong interest on the part of teachers to embrace innovation, to be more flexible and to be more versatile when teaching their subjects. Most of the interviewees, although not completely familiar with the STEAM method and the digitisation of teaching, welcome the production of new materials that are made available to teachers. According to them, on the one hand, this would allow a more fluid and interactive communication with students and, on the other hand, it would make it easier for teachers themselves by relieving them of the need to invent new materials and at the same time pay attention to the growth of their pupils.

We have chosen the Three stage model as the methodological approach to lean on when implementing science topics in learning lessons. Three stage model approach emphasises pupils' motivation in a way to make learning relevant. Relevance can be shown by linking science topics to a societal issue or issue that is relevant in pupils' everyday life. Motivation for learning is also increased by making it more attractive. Using art expressions for teaching science, among other benefits, adds also to the element of attraction. Three stage model approach is paying a great deal of attention to the development of pupils' awareness of being an important link in society and is encouraging them to be or become active citizens, capable of making reasonable decisions.

The OTA Methodology:

- is research-based, drawing on the researches of different pedagogical approaches and methods relevant when teaching/learning natural and science subjects;
- is taking inspiration from a Three stage model approach;
- encourages varied approaches and methods when teaching natural and science subjects;
- promotes art as a tool when teaching science and natural subjects;
- promotes STEAM approach;
- encourages learner-centred approach;
- encourages hands-on activities.

In the document below we describe the approaches and methods that underpin the OTA learning methodology and give examples and good practices as an inspirational material for implementation and conducting high quality activities.

2.1 WIDER CONTEXT

For pupils to become active citizens in the society, they have to learn some crucial skills from their early age. School is very important for pupils from the moment they step in the classroom at the early ages and till the moment they finish their education. It is a process that fulfils a major part of their days and a place to grow, learn, socialise and set the roots for their actions during schooling and later on. To achieve the goal for pupils to activate in serious societal matters, the school has to present a good example and prepare the inspirational path for pupils.

Active role for each individual in the society is getting more pronounced each year and the 21st century is emphasising a person's activation in different fields – especially education, being formal, non-formal, adult or even informal. Changes in the perception of educational processes are happening frequently but there are still gaps which need to be addressed and there is still room for improvements which can be fulfilled. Stepping in the educational process a pupil instantly becomes part of a system and it is expected that he or she will follow establishment, rules, tasks and guidelines. The most direct contact for pupils are their teachers; persons who went through an educational process of their own and are, of course, still learning, and at this point also teaching. On the other hand, teachers are as well part of a greater educational system with specific rules to follow: and the most straightforward are curricula. They are thus exposed to several different indicators: such as the examples they received while in school, the external curricula, the internal curricula that can vary from one school to another, and finally their own preferred intuitive approaches they use while teaching. Moreover they are also expected to improve, educate, evolve, upgrade and modernise; with new approaches and examples given, they can upgrade their lessons, reorganise their classes and add or improve existing objectives. For changes to be achieved, we have to speak to teachers themselves and enhance their willingness to improve. Motivation for changes can be achieved by showing them a greater meaning of new approaches and the positive consequences such approaches can have for pupils in a long-term meaning.

Projects, such as OTA, are in this sense very welcoming from various perspectives. Firstly, they address teachers' direct needs and challenges and try to help to overcome reported barriers, gathered through questionnaires and discussions. The needs are also examined through research on the topics. Additional values are also concrete examples which teachers can freely use in their classes with no or little extra work or they can serve as an inspiration on how to approach this or similar topics.

With the changes of teachers' approaches and their willingness to reconstruct their style of teaching following the suggestions and observing positive impact such changes have on pupils as well as on teaching itself, also an important step is taken toward the overall renewing of mindsets. Teachers are reporting several problems they are facing, such as: limited space to implement different activities without their filling that they compromise either curriculums' guides, their time for preparation or the time needed to teach certain lesson without cutting the important parts. In this way, OTA helps with saving time but also stays within a strong connection to the existing curriculum.

With the start of the pandemic because of COVID-19 the pre-existing problems gained a whole new dimension. Not only, the old problems didn't disappear, but all of the schooling had to be shifted in an on-line form and teachers had to bring their creativity in a completely, and for some of them even unknown, level.

How was OTA methodology conducted?

With methodology several issues and challenges when teaching science subjects were addressed. An important matter in teaching for OTA methodology is that all of the suggested methods and approaches are learner-based. With learner-based approaches we are stepping forward from the teacher being a narrator of theories toward a teacher being a guide. When pupils are presented with hands-on activities, they gain first-hand experience already in a classroom and the line for transferring their new knowledge in a later similar circumstance is thus shortened, moreover, their understanding of the topic is better and memorising stronger. Wondering, whether the result of the lesson will be shown whenever later-on and pass the test if it made a long-lasting impact, is somewhat fulfilled if the lesson is planned in a way, the results should be seen within its own proceeding.

Mathematics, Chemistry and Physics are subjects OTA project took for the basis. Those objects are part of the greater field in a society, known under the abbreviation STEM (science, technology, engineering, mathematics). Several recent years researchers are going toward an upgrade of this, now well-established term, adding A into the company. A is representing ART. Together they form STEAM. According to results from a questionnaire administered by OTA partners, teachers are not familiar with the term STEAM. Though the element of art in STEM company is proven to be an important addition (see the chapter on STEAM method 2.2). It is therefore important to emphasise the connection between mentioned subjects and art a step into a contemporary, in line with 21st century tendencies, also in primary and secondary educational process. Art as a powerful tool to help pupils' higher motivation, to help pupils to envision forms which can come across rather abstract when teaching or learning science and also to point out an undeniable bond those fields have completely naturally and spontaneously.

Packing the activities in a guided three stage model has several advantages. To name a few. Setting a lesson with a starting point that is not abstract but speaks to pupils directly, either coming from something they can easily relate to or to point out bigger societal issues, is the first step toward keeping their interest on a high level.

Preparing stage two, which is committed to the core of the lesson, with hand-on activities as a priority has higher potential to keep their interest going throughout the lesson, rather than losing their motivation and concentration in an abstract theoretical narration.

In stage three they should acknowledge the meaning of the lesson and the impact this new-gained knowledge has either for their personal life or for them, being an important part of the society. Pupils should see themselves as an important link that is constructing the future and see beyond the passive role. They should understand that the future to come is in their hands and that only their active role will lead toward a future, they would appreciate and like to live in.

The three stage model as it is developed in OTA methodology leaves a lot of room for teachers to implement their lessons. Following the suggestions should serve as an inspiration on how the subjects they are teaching can be approached. With explanations of different learner-centred methods and approaches in teaching, teachers should explore their options and reflect on how to use art as a tool when teaching science.

Further on, OTA being an up to date project is also addressing the barriers, teachers and pupils were facing, when pandemic hit the world and schools were almost immediately moved in a home environments for pupils as well as for teachers. Therefore, an on-line teaching and learning are addressed and implementation of the activities in an on-line environments is taken into a great account. With the digital era, we live in and counting the fact that on-line learning existed even before the pandemic, we can assume that in a post-pandemic world at least some forms of on-line teaching and learning will continue. Having strong bases and being prepared for this type of teaching and learning is an undeniable investment, especially now, when we experienced the worldwide situation of on-line education in all levels and are well aware of what kind of troubles it presents for educators and students.

2.2 STEAM METHOD

STEAM Science, technology, engineering, arts, and mathematics.

By now, the term STEM has already become a well-known term, which is connecting related subjects and can also be found in formal education around the world. Lately STEM got a new form – STEAM. STEAM is a method that is promoting interdisciplinary teaching, specifically for science subjects in combination with art. As the research in IO1 showed – a lot of teachers are thinking in favour of interdisciplinary teaching, but the majority is not familiar with the term STEAM. STEAM approach has been a discussion point in the education field in recent years. There are different views on what exactly STEAM stands for. We can come across the view, which sees A in STEAM as school subject ART, another view takes A for all forms of art and craft and the broadest of them all takes A as arts, meaning humanities in general (Piila et al., 2021).

By implementing STEAM approach in lesson plans several components are grouped together. From the OTA point of view, we use the STEAM approach to add art components in a company of Mathematics, Physics and Chemistry in a formal education environment. To achieve a high level of variety in that manner, elements from informal environments, such as galleries and science centres, are taken in consideration. Art is an entry point to science since it increases the value of science and makes it more effective.

In the research article *Hands-On Math and Art Exhibition Promoting Science Attitudes and Educational Plans*, written by Helena Thuneberg, Hannu Salmi and Kristof Fenyvesi, we can read about benefits of using STEAM approach in education. They are highlighting the imagination, which allows pupils to see things in different ways. Imagination is supposed to be enhanced by art, artistic expressions and making art itself. The aesthetic part of art creates an emotional reaction in this is likely to support also cognitive part of learning. The possible negative experiences and feelings, which can occur during learning, can be eased with providing pupils with that kind of experiences (Thuneberg et al., 2017).

Enhancing pupils' imagination is extremely important not exclusively for pupils who tend to appear more artistic or crafty. It is important also for those who are about to pursue their careers in other sectors. For scientists to be creative, for entrepreneurs to be innovative, etc.,

STEAM approach is used in education to increase pupils' motivation regarding science subjects. The interdisciplinary manner is supposed to enhance pupils' abilities for problem solving. For pupils' motivation and engaging in problem solving situations the concept of lessons should be formed as a problem, they really feel, could affect them. This is relevant for the success of the STEAM-approach. Familiarity with the situations increases pupils' motivation, thus improving the ability to find solutions to the presented problem (Piila et al., 2021).

Abstract issues in scientific subjects, especially mathematics, should find a way to become more concrete. Art is a way to provide such concretization as it is a visual form, thus more concrete or at least it appears so. "As the creative element and aesthetic component are the inherent core of art, combining art with maths learning offers an additional dimension for concretizing maths concepts ..." (Thuneberg et al., 2017, p. 2).

When we speak about STEAM pedagogical approach several components or, better said, benefits are considered. Firstly, to accompany science with art, we reach on a field of pupils' motivation to study science subjects, to approach science issues more willingly and to activate themselves more deeply. Not only does art provide an aesthetic component in a lesson, it also concretizes a given issue, so pupils can relate to it more profoundly. Art is surrounding us but it can go unnoticed. By emphasising its surrounding the connection to an out of school environment is established and to point out that this is also connected to a specific science issue we form a cycle, which is already a step toward the stages: from **society** to **school/learning** and back to **society**. Concretization of an abstract issue using art as an accessory is also a step forward of pupils understanding the very basics of science subjects, which are often forgotten as children grows older and the science subjects in school are becoming more abstract and more secluded and are exposed to division from not only non-natural science subjects but even between each other.

Benefits of STEAM are also in enhancing pupils' critical thinking. However, this cannot be achieved solely by using art in a school lesson. Art can be a good point to start asking questions and by those questions assure pupils can express their opinion in a safe environment. Safe environment should be established in any given circumstances, even when lessons are given online. Every pupil should feel comfortable to speak, respect others opinion, be aware that mistakes can also happen and should not be afraid to make them. This way also a communication is provided and a place for own creativity.

STEAM as an interdisciplinary approach is a principle the OTA project is driven from. The way STEAM is incorporated within the OTA project is: to use art as a tool to teach natural subjects (chemistry, maths and physics) in primary or secondary schools for pupils in an age range 12–14.

How certain art forms are used for specific subject topics depends on a lesson plan, topic itself, issue presented and the objectives of an individual lesson.

STEAM as a motivation,

STEAM to ensure better understanding through concretization,

STEAM for improving creativity,

STEAM for enhancing critical thinking,

STEAM for teaching pupils to be active citizens in a society.

2.3 THREE STAGE MODEL

Philosophy of "education through science" speaks in favour of educating science through societal point of view to learn the science knowledge and concepts important for understanding and handling socio-scientific issues within society. It encourages creativity, communicative skills, other personal skills (such as initiative) and development of social values related to becoming a responsible citizen and undertaking science-related careers (Holbrook & Rannikmäe, 2007, p. 1347-1362).

By establishing the THREE STAGE MODEL approach, education is coming from society to science and then from science back to society.

The concept of THREE STAGE MODEL, the OTA methodology is leaning on, is described in an article from 2014, written by Sormunen, K., Keinonen, T., & Holbrook, J. in *Science Education International* on pages 43-56.

Mentioned THREE STAGE MODEL (TSM) was instructional innovation of the PROFILES project (www.profiles-project.eu), which aims to arouse students' intrinsic motivation undertaken in a familiar, socio-scientific context (scenario), to offer a meaningful inquiry-based learning environment (inquiry), and to use the science learning in solving socio-scientific problems (decision-making) (Bolte et al., 2012).

The three stages are: 1. Scenario, 2. Inquiry, 3. Decision-making.

1. Scenario: In this stage pupils' intrinsic motivation should be aroused. This should be accomplished by presenting pupils the issue, which is relevant to their lives and worthy of greater appreciation. The scenario should be set carefully, coming out of pupils' everyday lives, a surprising phenomenon in nature or socio-scientific issue. The initial motivation forms a key launching platform for the intended science learning. It should set a base for scientific questions or other relevant questions for the topic.

2. Inquiry: should sustain motivation, set in Stage 1. It should meet learning outcomes through inquiry-based learning and enhance pupils' social engagement through collaborative teamwork. Consolidation is also part of Stage 2 and contains presentations of the findings, discussion of the relevance and reliability of the outcomes, interpretation.

3. Decision-making: the consolidation in this stage is meant to give acquired science ideas relevance by including them back into the socio-scientific scenario, which provided the initial pupil's motivation. Pupils reflect on the issue. It can be formed as an argumentation debate, role playing, discussion to derive a justified, society-relevant decision or consideration seen as reasonable by the class (Sormunen et al., 2014, p. 43-56).

One project that strives towards promoting interest and relevance is PARSEL (popularity and relevance of science education for enhancing scientific literacy). One possibility to make science lessons popular explored within PARSEL was to use every day related socio-scientific issues. In the context of the modules, popularity refers to students liking science lessons and wishing to study the subject in school. It also refers to liking science in general. Thus, an emotional component stems from the module and the way science is presented. It tries to address the concern – school science is not interesting.

Rather than the students being stimulated to learn by the teacher, the subject matter or external pressures e.g. examinations, PARSEL strives to promote self motivation by the students having an inherent desire to study the module. It attempts this by relating to students' needs and desires. An important component is assessment, which should take a step forward from the task being accomplished or not (Rannikmäe et al., 2010, p. 116-125).

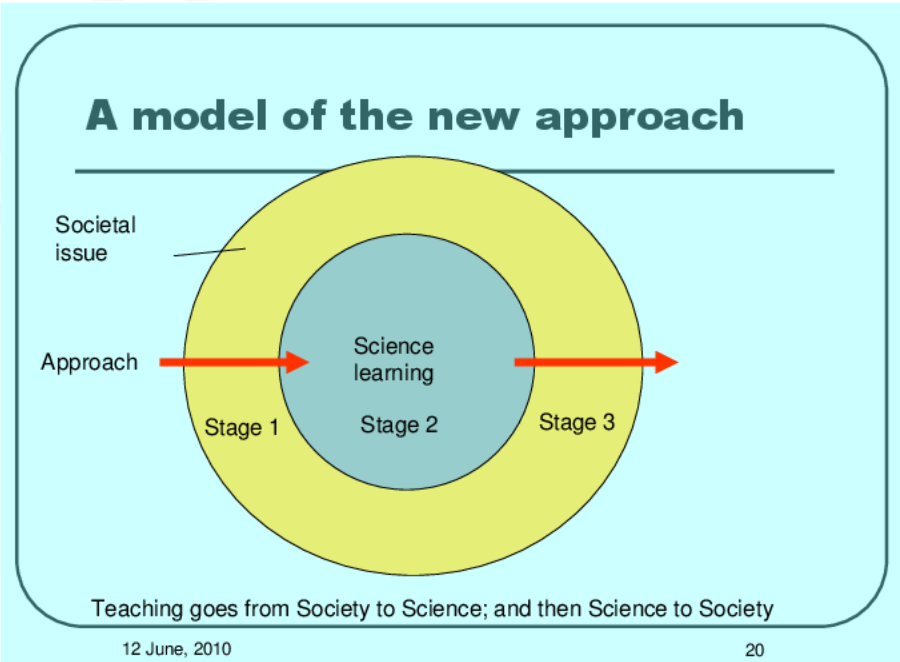


Figure 1: Source: Rannikmäe, M., Teppo, M., & Holbrook, J. (2010). Popularity and relevance of science education literacy: Using a context-based approach. Science Education International, 21(2), 120.

2.4 OTA METHODOLOGY

Three stages in OTA Methodology are coming out of those, structured in PROFILES project. The adjustments were made, when setting three stages, so they fit the needs of the OTA project.

First stage is emphasising pupils' motivation. If the motivation is carefully planned, pupils' intrinsic motivation arises and they feel their work in school is important and relevant to them. OTA project is taking this in serious account, when developing methodology, furthermore, OTA project is accompanying to this aspect also the letter A – art in STEAM. Therefore, the stage, where the motivation for pupils should be implemented OTA project sees as a opportunity for art to be given a voice. A scientific issue can be presented to pupils through art. It can be an interesting phenomenon, which pupils could observe in their habitats (e.g. Why are statutes green?). This is something that will raise their interest, because immediately they will connect science to a circumstance they experienced outside the classroom in what is likely to be understood as a "real life" to their perspectives.

After research on TSM proposed in the PROFILES project, the scenario set in the first stage seems to be a valid starting point for lessons. It is necessary to connect subjects from the curriculum to a situation that is familiar or relatable to pupils. Teachers are often faced with questions of a type "What good will this do to me in my real life?" etc. If we take these types of questions as a cry for help from pupils' perspective, we can quickly conclude that it is on teachers to show possible connections. With such an approach, we gain several benefits. Firstly, the question is answered, before it is even stated out loud. Secondly, pupils are taught to connect, link, observe and better understand the division between subjects in school's curriculum is not necessarily a reflection of other so-called real-life departments. Thirdly, the barriers of division are thus blurred and are creating paths for further connections pupils create in other situations – outside school as well as within other school subjects.

To ensure the motivation is set strong, the OTA project proposes that the first stage of school lessons is dedicated to this particular establishment. It can be formed in several ways. One of which is definitely setting the scenario, as PROFILES project suggests. Teachers showed some serious second thoughts, showing worries about length of time to carry out the whole lesson (Sormunen et al., 2014, p. 54). One of the crucial elements for the OTA project is that planned activities don't extend over a school-hour. Expressed time worries have to be taken into account, so the motivational stage doesn't feed off the time of other, also important, stages of school lessons. Propositions of formatting efficient motivational starting points are to create circumstances, where pupils are left with open questions to a proposed topic. A topic should be carefully chosen and also has to have a strong connection to a science theme, planned for the lesson. OTA project proposes, the topic is taken out of a world of visual arts, so the interdisciplinary approach starts as early as at the beginning of the lessons. To use art as a tool, though, it is not necessary to implement it in the first stage, especially if it doesn't make a lot of sense.

Art as a tool can have a significant role in the second stage of the school lessons. Expressing oneselves through visual art forms can leave a strong and long-lasting impression on pupils. When planning a second stage, some directions have to be considered. Second stage has to come as a natural follow-up to the motivational stage. Pupils' active participation should already be established within the (good) content in the motivational stage. To preserve pupils' motivation, this is the time where their curiosity should be stimulated. There are several teaching approaches that are appropriate for teaching science and are also very convenient when using art as a tool through which a specific topic from science class is taught.

One of the approaches that is particularly interesting for the OTA project is resource-based learning. OTA project, namely, is a teaching and learning form, carried out as remote classes. It is thus impossible to plan the lessons even in theory, without a serious consideration of resource-based learning, resource in this case being the internet.

For science lessons the inquiry-based learning is another approach that has proven to be efficient, especially when the word is of pupils' active participation in previously proposed topic. Inquiry is the action that leads pupils to better understand the question, while they independently search for an answer. (See section 2.7.5 of this document for further explanation). "Authentic inquiry happens when pupils are looking for answers to questions owned and, where possible, formulated by themselves. Inquiry can thus make a difference to pupil motivation." (Bolte et al., 2012, p. 11).

OTA project is following schools' curriculum, in particular the 4 curricula in 4 countries – Slovenia, Cyprus, Italy and Finland. Common topics in all four curricula were established through analysis in IO1.

Art as a tool is crucial for OTA project. How a certain form of art is implemented in school lesson depends on the formation of a specific lesson. It is important, though, that the teacher points out the implementation of art. Not to leave it as something self-evident but to talk about it with pupils and lead them to see and understand the combination of natural science and art. Two school subjects that are separated in curriculum and can from pupils perspective came around as something completely different and even incompatible, while in reality they have very much in common in terms of co-existing and dependence on one another.

The purpose of the OTA project is to raise pupils' motivation and interest in science subjects in their everyday classes – circumstances they are experiencing every day. The project aims to achieve this purpose using art as a tool when teaching science.

2.4.1 STAGES IN OTA METHODOLOGY:

1. **Motivational stage: Link of the topic from curriculum to a society issue that is seen relevant from pupils' perspective, issue linked to a phenomenon in nature or phenomenon from pupils' everyday life.**

Setting the first stage properly is one of the crucial points when planning school lessons. If pupils are presented with an issue that is interesting to them, they are more likely to actively follow the content of the school lesson. Thus, the issue has to be taken from something that is supposedly familiar to pupils, or a problem they feel are capable of solving. Pupils' active participation in resolving issues or solving problems is also one of the elements that increases their willingness to participate. Tasks should therefore be clearly set in a way that they follow the exposed issue and lead toward the second stage.

2. **Investigational stage: This stage is a natural follow-up of the first stage, where pupils take matters in their own hands, with aroused motivation to find the solution. To fulfil the task and find solution(s), pupils will strive for different teaching method(s).**
   Focus on subject topic, presentation of the art expression(s) used, setting objectives of the learning unit, leading the process through appropriate teaching method(s), which are not necessarily exclusive: creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning.

Second stage is the centre of the lesson. This is the stage where pupils' activities are in motion, their path of resolving issues and finding the solution. This is also a stage, where a room for open questions should be established. Teacher as a leader of the stages can in this stage also present any necessary information for pupils to follow tasks as undisturbed as possible.

3. **Consolidation stage: Reflecting the issues with chosen methods, such as discussion, argumentative debate, role-playing and deriving relevant decisions considering the above issue.**

In this stage, pupils are expected to link the scientific topic to an issue that was presented to them in the motivational stage. They are expected to conclude the lessons with a meaningful conclusion, whether being it an important decision, report on experiment's results observation.

OTA project is connecting art and science, so the topics from any of the science subjects (physics, mathematics, chemistry) are using art as a tool. Art as a tool can perform several roles. It can be a resource that connects science with everyday life

situations, thus a tool for motivation. It can be a tool for pupils to experiment and thus find the solution of a given problem. It can present an issue or problem itself in the first stage as the main character from which issue itself is presented in the first stage of the model.

To follow OTA methodology, learning lessons have to be prepared as an ON-LINE COURSE but also with possibility to be implemented in real life sessions. They have to be linked to art expressions and follow the three stages of OTA project, as identified and described above.

To follow three stages, lessons have to be linked to one or more societal issues or issues that are relatable for pupils. Art can serve as a presentation of a selected topic, serve as a tool for better explanation and understanding the scientific topic, which follows the curriculum. In consolidation state pupils are expected to find connection to issues, presented in the first stage.

OTA project will follow developed Methodology with providing lesson plans and activities for the topics of three chosen N&S subjects - maths, physics and chemistry. The topics were identified by teachers as the hardest to learn and/or teach during the Covid-19 pandemic, when schools closed their doors all over the world and were exposed to a sudden reconstruction of their classes in on-line courses. Activities will be presented in a form, where the three stages of OTA Methodology will be clearly exposed. Form will also provide a quick overview of important information, such as art expression used, approaches/methods used, timeline, equipment needed and concrete description of proposed activity.

Objective: The main objective of this methodology is to provide a framework of pedagogical principles for the development of practical examples for the topics in N&S subjects, which was reported to be the hardest for teaching or learning online in survey and focus groups meetings, done in IO1.

The overall objectives of the methodology can be summed up as follows:

1) To provide educators with knowledge, skills and understanding of implementing STEAM methods in their classes.
2) To introduce to educators a variety of approaches for teaching science and concrete learning activities that follow these approaches.
3) To introduce to educators innovative approaches which are focused on pupils' motivation and emphasising pupils as a part of society, enhancing their roles as active citizens.

Target Group: The target group of this methodology is two-fold:

1. primary target group: educators of N&S subjects of pupils in the age range 12–14.
2. secondary target group: learners within this age range.

2.5 IDENTIFYING THE ART EXPRESSIONS AND VISUAL FORMS TOOLS

ART EXPRESSIONS

Field of art expressions is wide and have variety of forms. With the use of artwork in school lessons we have several options. Art can be used as a starting point fort he whole lesson in the motivational stage, it can illustrate the core of the lesson's topic or present problem itself. It is important to have clear vision, what will selected artwork represent in the school lesson and how it will be used.

<u>Use</u>
Direct: artwork illustrates the subject, no in-depth context needed
Metaphor: artwork serves as a starting point for discussion, description and attention to its features needed
Analysis: artwork needs to be analysed to see the connections with the subject, its context is crucial for understanding
Abstraction: artwork and the subject are both systematically boiled down to the common denominator, which reveals the underlying practical and theoretical parallels and structures
<u>Source</u>
Natural world: depiction of flora, fauna, geography, cosmos
Human world: historical events, portraits and people, architecture, customs and traditions
Religion: supernatural events, myths, legends, miracles, religious milestones
Literature: depiction of events, characters and themes from novels, stories, poems, epics, essays, plays, etc.
Theory: art about art, psychology, colour theory, reception theory, etc. (e.g. abstract expressionism, neoplasticism, surrealism)

Art expressions can come from pupils themselves. There can be a task given in the school lesson, where they have to incorporate their own artistic expressions by making a piece of art.

Art expressions that pupils make can come from a different field of art: for example painting, drawing, collage, sculpture, their own artistic video, computer art or other art forms, not necessarily from the field of visual arts (such as poems or other creative writing, creating music) or combination of different art expressions (for example: art projects, installation). When implementing the type of task, where pupils own art expression is expected, it is important for OTA project to keep in mind, that the materials for pupils have to be easy reachable (preferably what is expected to be at homes) and not expensive.

VISUAL FORMS TOOL

STYLE

Planar: subject is mentally transformed according to an ideal order and is presented as permanent, motionless, unchanging (Ancient art from the Middle East, Mediaeval Art)

Plastic: realistic depiction, which includes shading, correct perspective and can inform other human senses (Renaissance, Roman Baroque, Neoclassicism, Biedermeier, and Realism)

Painterly: recapturing the visual impressions, with sharp outlines lost, and the image made of patches of light and colour (Mannerism, Venetian Baroque, and Impressionism)

Technological tools

REPRODUCTIONS (DIGITAL AND ANALOGUE)

Quality reproductions are crucial, both in digital and analogue forms. Open-source files available on Wikipedia, sites of larger international museums; contemporary works might be subject to copyrights.

INTERACTIVE WHITEBOARD

Should include features to draw on, cut and colour filter the reproduction while using it in class.

HOME-MADE VIDEOS

Numerous social-media apps allow users to prepare short videos - can be used by pupils or by the OTA project to create intros for online lessons.

2.6 LEARNING OBJECTIVES

The STEAM methodology aims to revolutionise the traditional concept of teaching because it substantially changes its connotations and the position of those involved. The classical face-to-face approach develops its potential in the dual relationship between teacher and student, where the established relationship is one-to-one and hardly open to others.

The STEAM methodology goes over the classic vertical and hierarchical teacher-pupil relationship by proposing a more inclusive approach in which circular knowledge is established, where learning is more equitable, flexible and interactive.

With the use of the interdisciplinary STEAM method, students will not only be "receptors" of knowledge, but will also be able to create knowledge thanks to the experiences, empirical, that they will make; students will be an active subject in the learning process, with greater motivation to learn and greater probability of realising their potential and abilities.
Art, science and technology are creative, generative activities, which together tell the purpose of an innovative and interdisciplinary approach to research and teaching.

LEARNING OBJECTIVES

Albert Einstein wrote: "Where the world ceases to be the scene of our personal hopes and wishes, where we face it as free beings admiring, asking, observing, there we enter the realm of Art and Science.
If what is seen and experienced is portrayed in the language of logic, we are engaged in science.
If it is communicated through forms whose connections are not accessible to the conscious mind but are recognized intuitively as meaningful, then we are engaged in art.
Common to both is love and devotion to that which transcends personal concerns and volition".
In the traditional method of teaching, students are forced to adapt to the complexity of studying specific subjects; but it can happen that they lose interest within the class or have difficulty keeping up with other classmates; on the other hand, it is certainly not easy for teachers to make up for the gaps of some without sacrificing the learning of others.

An interdisciplinary method such as STEAM, based on a **student-centred system**, allows the student to approach the complexity of the subjects of study in different ways and from different points of view that might seem simpler to him, and also encourages the acquisition of a set of skills that are functional to the personal growth of the student.
The change from traditional education lies precisely in this: in emphasising and stressing the interests, skills and learning styles of ***each individual student.***
Additionally, it allows teachers not to be alone in this teaching process and to be able to diversify the language with which they explain the concepts.
STEAM approach allows students to explore their personal learning styles, connect the subject matter with their interests, find new learning approaches that work best for them, strengthen their **self-confidence**, their **ability to analyse**, **and critical autonomy in thinking and acting.**

The STEAM method brings with it a number of characteristics that enable the development of certain key skills for students. The key characteristics are:

- Multidisciplinary
- Collaborative
- Flexible
- Inclusive
- Students-centred
- Creative
- Coherent, Critical
- Interactive
- Fun

Each of these characteristics is a precondition for developing and strengthening the following competencies:

- Developing critical and reflective thinking
- Learning to learn
- Understanding connections
- Collaboration and communication -> Encourage inclusion; foster socialisation
- Flexibility
- Empathy
- Self-confidence
- Self-efficacy
- Patience
- Autonomy
- Creativity
- Problem solving

Characteristics of the STEAM approach	What does it mean?	Learning objectives
Multidisciplinary	The STEAM method is defined as a method or approach and not as a discipline because it works on a wide range while recognizing the importance of individual disciplines as well as the interaction between them and the reality that students live. The STEAM approach is therefore transversal, embracing at the same time several different subjects and avoiding reasoning and creating unproductive	• Reflective thinking • Learning to learn • Metacognition-Understanding connections

	compartments between the various disciplines. The transdisciplinary nature of the method therefore allows it to focus on the individual student's commitment and the achievement of specific learning objectives.	
Collaborative	The STEAM approach encourages group work and stimulates collaboration not only among students but also with teachers who become part of the learning process and are in constant communication with students and colleagues.	• Collaboration • Communication
Flexible	It is a method that allows freedom of movement to teachers who can be free to modulate their activities and lessons according to the class and the needs with which they interface. The only common thread linking the individual subjects considered is communication and dialogue. Teachers will therefore be called upon to guide this dialogue and always stimulate the critical thinking of students.	• Flexibility
Inclusive	The STEAM approach fosters inclusion and the emergence of the talents and potential of the most sensitive and introverted students who, outside the logic of the classroom, are able to produce more results.	• Empathy • Self-confidence • Self-efficacy • Patience • Autonomy
Student-centred	Students are encouraged to participate fully in a stimulating and welcoming environment where there is no fear of aseptic judgement. The figure of the teachers within this process is fundamental because it is thanks to the teachers that this climate will be	• Autonomy • Self-efficacy • Learning to learn

	established in which in addition to a vertical teaching (proper to the traditional method) will promote a horizontal learning process.	
Creative	Approaching creativity and encouraging students to be creative is the essential aspect found in the STEAM method. Teaching students to approach theoretical concepts within the curricula in a creative way means giving them the foundation to apply this way of approaching things to life outside of school.	• Creativity • Innovation • Problem solving
Coherent, Critical	The STEAM approach inevitably needs internal coherence and compatibility within the curricula of all subjects with the subjects. At the same time, it must approach what students will learn critically, including through experimentation with what they study.	• Critical thinking • Problem solving
Interactive	Learning by doing: students will experience a type of experiential learning, through doing. This method will be based on different factors that are equally important: concrete experience; observation, reflection, the formation of abstract concepts and the replicability of the method in different contexts.	• Communication • Collaboration • Critical thinking

Fun	The interactivity of the STEAM approach makes lessons more fun and stimulates the curiosity of students who will be more motivated to learn. By increasing the level of attention and motivation of the students, thanks to activities/quizzes/games, the STEAM approach allows them to reach the specific learning objectives in a faster and more profitable way by stimulating inventiveness, communication and teamwork.	• Collaboration • Problem solving

2.7 SELECTED TEACHING METHODS AND APPROACHES EXPLANATIONS

2.7.1 RESOURCE-BASED LEARNING

Resource-based learning (RBL) is particularly interesting as we speak in terms of online teaching and learning as it emphasises the use of any given resources in the teaching process. When we move our lesson from a live environment to an online type of lesson a world of infinite new resources opens.

Resource-based learning is a view, which gives prominence to the role of resources in the teaching and learning process. RBL conceptualises learning as a process which foregrounds the importance of the resources available to learners. When speaking of RBL, there are presupposes that the interaction between the learner(s) and the resources (including human resources) is the main structuring device of the learning situation (Esch, 2002). This aspect is important for OTA project, as the project focuses on development of on-line courses, thus, the basic resource is the internet itself. That said, OTA does not see resource-based learning as a stand alone approach but rather as an inevitable condition, which has to be completed in order to lead an on-line courses, whether being live or pre-prepared. It is also something schools, teachers and pupils had to have during the pandemic to continue the process of schooling even when schools as buildings and places to go to were physically inaccessible for everybody.

While resource-based learning as a term exists for a longer period among educators and researchers, it was the beginning of the digital era that gave additional attention to this learning approach.

Since we entered the digital age, or better said, since the digital age expanded to almost inevitable width, the nature of resources has also changed. We are provided with a larger number of opportunities. They are more available and also provide several different perspectives. We now have access to more traditional and historic resources (e.g., books, articles) and also contemporary (e.g., daily news) information sources (Hannafin & Hill, 2007, p. 527). The digital age has redefined and transformed educational resources. Resources are now exposed to modification and have much easier access than in previous eras. Even more, they can be even created and easily shared to a wider or limited public. They can and are assembled from virtually anywhere to address individual goals and needs (Hannafin & Hill, 2007, p. 526).

After the pandemic hit the world, even the most resilient institutions had to adapt and became equipped with the most recent and usable resources so they could keep in touch with their persons of interest. Even the most unexpected institutions, such as Theatres, Puppet Theatres and Nightclubs, did their best to offer some kind of interaction. And schools were no exceptions. Even teachers who never thought they'll use digital resources of such measure, adapted and stayed in touch with their pupils and parents.

The spread of the internet brought a different way of thinking. Its significance in educational systems became of greater importance during the worldwide on-line learning. At that time, even teachers and other educators who were at that time resisting the use of technologies in teaching were forced to form their lessons online and gained necessary skills to be able to do that.

Resources being more accessible also have another dimension. They also became easy to produce. So the cycle goes round. Given resources can be used as a tool in education, but also pupils or educators can easily provide their own resources and present them digitally.

Resource-based learning aims to enhance pupils' active engagement in learning units and provides learning space, where pupils are free to experiment, research, deepen and search for certain information in a very open way – which depends on the amount of resources available for pupils. Teacher in this type of teaching has the role of a guide. One can implement resource-based learning in different ways. It can be set as an open environment and with unlimited resources. Whatever pupils' think would serve them best for a topic they are researching or issues they are solving. Whether resources chosen were appropriate or not must be discussed with the teacher (educator) during the process. It is expected that pupils present their findings or results at the end of their inquiries and the effect of unappropriated selection on other pupils should be avoided. Teacher has to be present in all steps and keep control of pupils' processes so their work is on an appropriate level and without possible disinformation. Nevertheless, they have to act as an active part of the lesson and fulfil given tasks as independently as possible. Thus, their creative thinking is empowered and they are solution-oriented.

Resource-based learning can be planned differently – in a more guided way. The teacher can make a preliminary selection of all reliable resources (including appropriate Webpages). This way, more control of relevant information is formed and also the level of difficulty of resources is assigned by the teacher this way (Campbell et al., 2001). Such an approach is especially appropriate for younger pupils as they are not yet proficient readers.

If the teacher provides or suggests several different resources (digital or printed, photos, different books etc.), pupils should select the most appropriate resource. If not sooner, the moment where a pupil has free choice of selecting resources is the moment when their active participation is established. Whether they'll have completely open hands on selecting resources, whether they'll select one or more resources lies partially on the teacher's choice, partially on the topic/issue of the learning lesson, partially on the structure of the learning lesson itself.

Resource-based learning is not meant as a stand alone learning approach or teaching methodology (Hill & Hannafin, 2001). It is more likely to be mixed with other approaches, such as inquiry-based learning or problem-solving. It can serve as a starting point or as a support during the process of inquiry, research.

For OTA project, resource-based learning is important from a point of view of the digital age. OTA project lessons are meant to be implemented as online lessons as the project aims to support the difficulties of an on-line teaching and learning that came across during the worldwide on-line education as a consequence of a COVID-19 pandemic. Thus, the internet itself is an inevitable asset. To follow one of OTA crucial elements when designing activities: "low cost materials that are possible to find at home" the advantage of internet access seems to present itself and is indeed convenient. To actively engage pupils, the internet does not only serve as an information provider, but it is also a tool for producing material, such as presentations, videos, photos etc. and has an enormous potential to keep pupils creative, active and focused. That said, the potential of the internet for pupils to misdirect them should not be ignored. Therefore, the planning of lessons should be precise, with clear instructions and time limit to prevent as many pupils' departures from the topic as teachers can while teaching remotely.

Combining RBL with art to teach science subjects:

Resources such as easy internet access allow teachers as well as learners to find an infinite amount of all sorts of artwork. From famous virtual galleries to street art and personal art from rather unknown artists on portals such as Pinterest, Artsy, Instagram etc.

Teachers can plan a lesson that requires knowledge of a specific artwork or investigation of them. For example: Find a building that has different angles in its surface than 90° …

2.7.2 EXPERIENTIAL LEARNING

In 1938 John Dewey wrote a book, titled Experience and Education and it is said to be a foundation for discussions of experiential learning. In Dewey's experiential learning theory, everything occurs within a social environment. Knowledge is socially constructed and based on experiences. This knowledge should be organised in real life experiences that provide a context for the information. The teacher's role is to organise this content and to facilitate the actual experiences. The experiences are based on the capabilities and readiness of the learners. The quality of the experience is the most important component of the theory. Upon completion of an experience, learners have the knowledge and the ability to apply it in differing situations (Roberts, 2003).

David Kolb wrote a detailed research on experiential learning in 1984 titled Experiential learning. His theory was made by examining, researching and comparing three other pedagogical theoretics: the above-mentioned Dewey, Piaget and Lewin. Through experiential learning theory, he wanted to suggest a holistic perspective on learning that combines experience, perception, cognition and behaviour. He developed a theory for learning as a 4-stage cycle: **concrete experience, reflective observation, abstract conceptualization and active experimentation.** Learning is effective after the learner goes through the cycle. Learners can enter into the cycle at any time (Kolb & Kolb, 2013).

Experiential learning is closely connected to hands-on learning or learning by doing. Main difference between those approaches is that experiential learning is taking a step forward and emphasises learning through a metacognitive process; pupils enter when reflecting on their actions. This way, knowledge is more deepened and has greater potential to be later transferred to everyday life situations.

When learning is conceived as a holistic adaptive process, it provides conceptual bridges across life situations. It can serve also for portraying learning as a continuous, lifelong process (Kolb, 2014, p. 45).

Experiential theory sees learning as a process whereby knowledge is created through transformation of experiences (Kolb, 1984, p. 38).

Learning through experiences is important in many aspects. When experiencing something, the ability of understanding is much higher than through theory only. Educator's role in experiential learning is to provide the learning environment.

When educators take into account experiential learning, they can give their learners concrete experience from which they can learn about new material. Using pre-gained experiences, they implement new ones and thus create knowledge with the help of transformation. Important is that they can see this experience as an important asset in their everyday lives.

OTA methodology will use this aspect giving learners experiences on how to transfer art to science and vice versa. Coming out of an interdisciplinary approach, the learning field is well set, because immediately the learner has to enter complex thinking with connecting knowledge from other fields with the field of interest. Having the experience on how to transfer experiences among different fields, it will also be good practice for pupils as a life-long competence, meaning to transfer the in-school experience in an environment outside school, the environment pupils see as real-life as much as being in school, if not more.

The examples of experiential learning activities include **field research, classroom activities, off-site school trips, project-based learning, field activities, experiments, simulations, field trips.** When planning on-line lessons, we can easily assume that those non-formal activities, which take a lesson outside school's environment, will have to be cut or somehow adjusted. By implementing a learner-centred approach, where one of the components is that the pupil draws from previous experiences and makes a link, connection with current issues, is one of the possibilities. Teacher's role is to guide pupils toward such an experience and set a clear field for them to make a connection. Out of this connection, pupils form a new meaning by combining previous experience with new knowledge, which has a greater potential for pupils' overall understanding of a matter as well as enabling skills for life-long learning. For an on-line teaching drawing from previous experiences is crucial, especially when the teacher is faced with a lesson, where an introduction of an out-of-school environment is necessary.

Other solutions for such lessons are also possible nowadays and especially during pandemic. A lot of institutions had established an on-line visitations of their offers even before the pandemic, but in the time of the major lock-down, this became a regular practice. Especially for institutions such as galleries, museums, even there and similar. A lot of them also shut down their on-line offers, after they were able to open the doors to the public again, but there is still a great amount of offering institutions and teachers should use this as an advantage when they implement on-line courses.

In the OTA methodology, we are researching options to provide a toolkit for online activities, so we will pay special attention to the experiential learning, since this is the component that can be much compromised when learning on-line.

Combining Resource-based learning (internet) and experiential learning with art to teach science subjects:

We can set up useful and effective activities. Pupils get knowledge through experiencing artistic expressions as well as assigned topics from a field of science.

Find a building that has different angles in its surface than 90° using internet. Show image, explain the angles. Look around your room/house/apartment/classroom. Find objects with similar angles. Show the object (or take a picture if it's too big). Compare the two. Explain similarities and differences. What is this object used for? Are the degrees of the angle important? …

2.7.3 CREATIVE PROBLEM SOLVING

PROBLEM SOLVING

Problem can be described as an occurrence when our brain identifies specific circumstances as something that needs to be solved.

Problem solving is a process: it is the act of defining a problem; determining its cause; identifying, prioritising, and selecting alternatives for a solution; implementing a solution.

In the problem solving process, it is important to distinguish a problem itself aside from the symptoms. Source: https://asq.org/quality-resources/problem-solving

After defining the problem, the brain enters the analysis stage of the problem solving. Problem has to be understood first, before it can be solved.

In 1972 scientists Newell and Simon set some ground for understanding problem-solving. Their analysis of means-ends problem solving can represent general characterization of the structure of human cognition. Means-ends analysis seems to be the prime method of human, when exposed to problem solving (Anderson, 1993). Means-ends analysis is a process in the human brain, when a person acknowledges more or less complex problem, envisions the best possible solution or defines a goal, and after that creates a strategy on how to achieve the goal or resolve the problem.

The Tower of Hanoi (Figure2) is actually a toy, but it has somewhat complex rules or restrictions and a clear goal. Humans tend to use means-ends analysis, when exposed to a task of Tower of Hanoi and it is a representative technique on showing how the brain works. When trying to achieve the goal of the game, following the instructions, sub-goals are set.

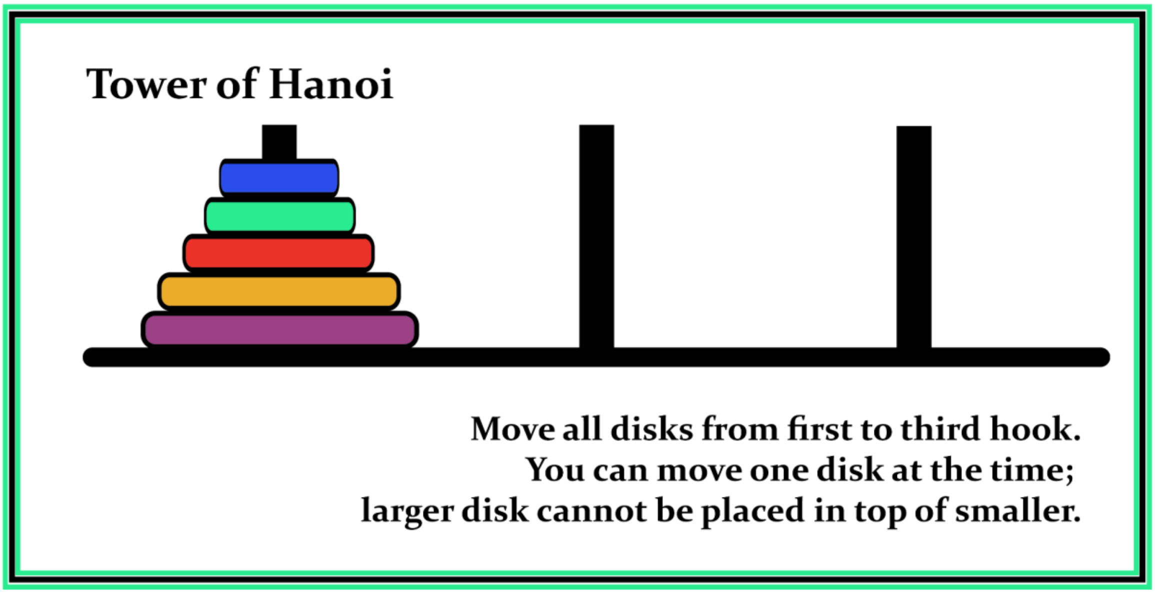


Figure2: Sketch - Tower of Hanoi

Source: own

Based on Newel and Simon's characterization of problem solving, the main term in problem solving is PROBLEM SPACE, the space where the problem solver is gathering solutions. A problem space has an initial state, a goal state, and a set of operators that can be applied and will move the solver from one state to another (Anderson, 1993).

People often use heuristics for searching problem spaces. (Dunbar, 1998). Heuristics are methods for solving problems based on the previous experiences in order to solve problems as quickly as possible in the way that is still acceptable but not necessarily optimal. However, modern authors' opinions are that heuristic's solutions are good enough and furthermore, in certain circumstances, can be even more accurate than more complex methods of problem-solving (Hozjan, 2012).

The problem-solving methods provide the mechanisms for converting knowledge into behaviour, including cognitive behaviour (Anderson, 1993). Coming from that, if we provide lessons that require problem-solving activation, or in other words – if we teach problem-solving skills, we teach pupils how to behave in specific circumstances. By showing them relatable circumstances, we take a step further, to achieve the main goal of problem-solving education –that pupils will eventually be capable of independently solve problems they will face during their lifetime.

What so often counts most in schools is the important but incomplete cognitive resource of knowledge. Fixed knowledge and algorithms are easier to teach, learn, and test than is the tangled web of processes that make up problem solving. Typically, it is not before graduate school that problem solving really becomes the focus of an educational program. Even in graduate school a student may not get to wrestle with the true problems of a field of study until the dissertation (Martinez, 1998).

One of the subjects, responsible for developing problem-solving skills within the education system, is mathematics. Pupils should develop divergent thinking skills and mathematics teachers should teach them exactly that. The goal is not only to show pupils the way to solve problems, but to encourage and activate them to think also about the possibilities of the way or ways themselves: in this way the whole brain of pupils is activated and they don't simply follow the instructions. As a matter, following the instructions and getting the result or salvation can certainly provide a sort of level of satisfaction among pupils but it does not necessarily guarantee a long-term understanding and the ability to reflect this sort of brain engagement in other life situations. On the contrary, when the pupil activates the whole brain by thinking about how he or she can come to a certain solution, the experience is stronger, the understanding of the problem deeper and the possibility to transfer the gained skill to other life situations increases. By setting the scenario of the problem (or issue) in a situation that is familiar to the pupil in the first place, intrinsic motivation for activation is higher, they engage themselves in experience, activate their brain in a thinking process and lead themselves toward the solution.

CREATIVE PROBLEM SOLVING

Creative Problem Solving is a way of thinking and behaving. CREATIVE – an idea that has an element of newness or uniqueness, at least to the one who creates the solution, and also has value and relevance. PROBLEM – any situation that presents a challenge, an opportunity, or is a concern. SOLVING – devising ways to answer, to meet, or to resolve the problem.

CREATIVE PROBLEM SOLVING or CPS is a process, method, or system for approaching a problem in an imaginative way and resulting in effective action (Mitchell & Kowalik, 1999).

One of the most important processes, which explains the creative problem solving process, is the Osborn-Parnes creative problem solving process. Osborn-Parnes Creative solving process is classified as following phases: **1. Finding an object which is the phase of defining the area of the problem. 2. Finding the reality, which is the phase of obtaining data. 3. Finding the problem, which is the phase of defining the problem accurately. 4. Finding ideas, which is the phase of generalising the solutions in the problem, 5. Finding the solution which is the phase of assessing all the possible**

solutions and making selections among them; 6. Finding the acceptance, which is the phase of application of selected ideas correctly (Kandemir & Gür, 2009).

Although CPS can be applied individually, problems are often most effectively solved in a team, where brainstorming allows for more ideas to be generated. Thinking of many ideas is critical to effective problem solving using the Osborn-Parnes model (Mitchell & Kowalik, 1999).

For OTA creative-problem solving is an ability that allows a certain measure of uniqueness. When we encourage pupils in a creative problem-solving way, we should not expect their ways to be similar to one another or even to the way we see it ourselves. Creative problem-solving should leave room for different interpretations of the same matter. It should allow pupils to find their own paths and have an independent approach. Traditional learning was often set in a way that teachers showed a chosen way of solving exposed problem and pupils were following their lead. The passiveness of pupils in such a way of teaching can result in learning by heart without giving any emphasis on basic understanding of "how" and "why". Also this can leave negative consequences on post-school life as it encourages pupils to be a passive perceiver. There are pupils who are naturally creative and will actively participate with teachers' solutions, give their suggestion self-initiative and maybe provide a good example for their peers. However, we must not forget that those are not all pupils. If we are following the goal to encourage pupils to be active citizens, we have to eliminate passiveness in the classrooms and reform it to a participatory, active and engaging shape. We have to ensure that also pupils who tend to become passive quickly are fully engaged the whole time of their schooling. Educators should see this as their responsibility, because they are in direct contact with pupils and can leave a strong life-long impact.

With teaching and encouraging creative problem solving pupils' minds are challenged. This means pupils are not presented with one way of dealing with a given issue but have an open way to discuss possibilities on how certain issues can be solved. As mentioned before, the creative problem solving is a good team activity. How the team approaches an issue is of their own choice. But there are some techniques that can be useful, such as brainstorming, setting the issue in another environment, redefining the context of the issue (for example: they have to form a Newspaper article out of a topic from a scientific subject), forming "What if?" questions (what if my house collapses if I don't solve this problem), visualising an abstract scientific issue (giving it a name, think of it as a pet).

Creativity is often associated with art. Any form of art to be precise. The OTA project does just that. Art as a tool to teach science can improve pupils' creativity, especially when their task is to provide their own art-form, connected to the scientific problem they have to solve. Keeping pupils active in a creative way is important in all school processes. Pupils should be encouraged to think creatively at their earliest ages, thus providing a strong roots for latest schooling and life-long learning.

Creative problem solving is solving problems out of an ordinary and conventional way, allowing yourself to see outside the box and find solutions elsewhere in a unique way.

2.7.4 EDUCATION THROUGH SCIENCE

Authors Holbrook and Rannikmäe, in particular, use the term Education through science, rather than Science through education. The differences between the two are that education through science is focused on the socio-scientific issues within society, while science through education is learning about fundamental scientific theories, laws and concepts. ETS is emphasising the relevance of science in the society and is trying to increase learners' interest in the topics by speaking to the concrete issues and thus showing the importance and needs of science for societal existence, evolving and improving.

ETS as well as STE aims to develop a positive attitude toward science, the difference is that ETS is arising from society and is taking learners' understanding of that as an important part to be addressed and implemented in the educational process.

Within ETS also the term scientific literacy is discussed. Scientific literacy in this context is being understood as more than just a knowledge and understanding of science, it sees the "responsible citizenry as a major focus in which scientific knowledge is used wisely for the benefit of society. It strongly includes the personal and social domains alongside the nature of science." (Holbrook & Rannikmäe, 2007, p. 1347-1362).

SCIENTIFIC LITERACY

In the school context, it is extremely difficult to distinguish between scientific literacy and technological literacy, as the two go together (technology is not intended to simply refer to computers, or the simple acquisition of technical skills, but to the man-made materials and processes developed within society). In fact, for all practical purposes related to the teaching within schools, scientific literacy and technological literacy can be taken to be the same. This does not mean that science is the same as technology, far from it. But it does suggest that the conceptual knowledge, personal and society values inherent in the development of STL in this sense are indistinguishable (Holbrook & Rannikmäe, 2007).

Scientific literacy should be linked to important elements: an appreciation of the nature of science, personal learning attributes including attitudes and to the development of social values (Holbrook & Rannikmäe, 2007).

Relevance of the learning plays an important role for increasing pupils' scientific literacy. Teaching materials, thus, need to consider a societal frame, introduction of conceptual science on a need to know basis, and embrace the socio-scientific situation that provides the relevance for responsible citizenship (Holbrook & Rannikmäe, 2009). Developing pupils' responsibility and consciousness is an important factor in the educational environment and by enhancing scientific literacy teachers can have an influence on pupils' actions at the given moment and also in a further future. With better understanding of science and capability to link science to an everyday life and further to the environment in general, a chance for pupils to understand their role in the society and become active participants, have influence on changes and improvements is greatly risen.

VISUAL LITERACY

Visual literacy is the ability to find meaning in imagery. It involves a set of skills ranging from simple identification--naming what one sees--to complex interpretation on contextual, metaphoric and philosophical levels. Many aspects of cognition are called upon, such as personal association, questioning, speculating, analysing, fact-finding, and categorising. Objective understanding is the premise of much of this literacy, but subjective and affective aspects of knowing are equally important. Visual literacy usually begins to develop as a viewer finds his/her own relative understanding of what s/he confronts, usually based on concrete and circumstantial evidence. It eventually involves considering the intentions of the maker, applying systems for thinking and rethinking one's opinions, and acquiring a body of information to support conclusions and judgments. The expert will also express these understandings in a specialised vocabulary (Yenawine, 1997).

An important factor in education is the relevance of specific topics, meaning that learners recognize the relevance of learning those topics for their personal needs or goals. With emphasising relevance, learners' motivation grows especially intrinsic motivation (Holbrook & Rannikmäe, 2009).

As educators, we can achieve the understanding of relevance with techniques such as interdisciplinary approach. With OTA methodology, the interdisciplinary approach is addressed by combining two subjects that are usually taught separately: art and science, specifically art and chemistry, art and mathematics, art and physics. From this point of view, both above mentioned literacies – scientific and visual, are important for

OTA learning methodology, because it is addressing the usage and development of both.

Visual and scientific literacy will evolve through tasks and set problems, alongside the awareness of importance/relevance while learners will enter complex thinking using two fields and accepting them as one. With an interdisciplinary teaching mindset of a world functioning as a whole is strengthened rather than thinking of specific subjects as independent units. The element of coexistence of different fields is important for addressing especially in educational systems where subjects are separated in different units. Learners have to realise soon that just because they have scheduled e.g. mathematics and geography separately it does not mean that they don't have anything in common. With such realisation, also a transfer in real life situations becomes easier for learners especially if they are given the concrete problems to solve that are a combination of several different subjects/fields.

For the element of relevance Halbrook and Rannikmäe are suggesting also "that science in school is part of the education provision and any science content is gained so as to enhance that education in the nature of the subject, the personal or the social domains."(Holbrook & Rannikmäe, 2007, p. 1347-1362).

The inclusion of personal and society domains into the learning structure are expected to enhance the relevance of science teaching. This is not an explicit approach and Activity theory is providing a stronger theoretical construct of it.

Activity theory as the tool to address that lack of relevance in school science is based on the interlinking of knowledge and social practice through establishing a need (relevant in the eyes of students), identifying the motives (wanting to solve scientific problems and make socio-scientific decisions) leading to activity constituted by actions (learning in school towards becoming a scientifically literate, responsible citizen). Such practices are meant to provide for student needs (as perceived by students insofar as this is possible, otherwise perceived by society as an area of need) in a more or less organised way by making 'products' or 'decisions' from 'raw materials', scientific components, or issues to resolve. The activity can be 'enquiry process' or 'debate'. It is a way of educating students how to make proper decisions. The decisions they make through their learning process should take into consideration the needs of all members of the society. An important part in activity theory is also reflection as a way of improvement in practice or making decisions (Holbrook & Rannikmäe, 2007).

2.7.5 INQUIRY-BASED LEARNING

As the name refers, inquiry based learning is coming out of methods used by professional scientists. It is a process of discovering by establishing hypotheses and testing them with experiments and/or observations. It is closely connected to a problem solving process as it requires problem solving skills.

Inquiry-based learning strongly defends pupils' active participation in their educational process and places part of responsibility also on pupils' to discover new knowledge themselves (Pedaste et al., 2015).

There are several benefits with setting school lessons as an inquiry environment. Such an approach achieves better understanding of abstract forms, such as ideas, concepts, thoughts. It also increases pupils' motivation for participation and activation, while also developing intellectual and practical capacities. That said, inquiry may take more time than more traditional methods in terms of preparation as well as implementation. While this could present a problem for teachers, since they are reporting a lack of time, the solution may come out of teachers themselves. They should be prepared to experiment with their own practice. Inquiry should not be an all-or-nothing activity but a part of a repertoire of different actions, aiming to improve outcomes of pupils' knowledge, understanding, motivation and activation (Bolte et al., 2012).

In a section of resource-based learning, it was already pointed out, how much digitalization of the society influenced not only pupils but also the way of learning, reformed pre-known teaching approaches and also opened the whole new options for teachers and pupils.
By digitalization, inquiry-based learning gained popularity in the science curriculum. By technological developments, the inquiry process can also be supported by electronic learning environments (Pedaste et al., 2015). This is also a case when learning is happening on-line. Especially during the pandemic.

Inquiry-based learning is an approach which encourages pupils to actively engage in problem solving. The problem or an issue that is presented by a teacher should be undertaken in some sort of investigation and it is pupils responsibility to solve it. As many other approaches, inquiry-based learning is also putting pupils first and considering them as an important part in finding solutions. Often, the way to the solution in inquiry-based learning is through experiments: pupils learn through hands-on experiences and the options for them to see the importance of such a lesson ,or science subject in general, is thus improved, especially if a noticeable amount on pupils' own evaluation is given. By communicating through their processes, they acknowledge all the phases in the processes, possible mistakes through their experimentations or other kinds of examination/research and the results gained at the end of the process. And also results and paths of their peers.

We cannot ignore the fact that if lessons are taken in classes with provided electronics, the circumstances are more or less the same for all pupils, but when we expect pupils to learn from homes, there can be several issues which can make learning difficult for pupils with less privileges. Issues that were exposed during the pandemic are – a lack of internet connection in more secluded places, no internet because of money problems, slow internet connection, no camera, headphones or speakers, no computer, no device to connect to on-line classes, time management (especially in a families with 2 or more children, where also parents had to work remotely). These are external reasons, but there were also a lot of problems with pupils' motivation, when they had all other conditions fulfilled.

2.7.6 ONLINE TEACHING AND LEARNING

Online (also remote, distance) learning is present for a long period of time. It started even before the digital era with some preceding examples of distance learning as early as in the 1950s (Lockee, 2021). With the internet also online education was born and as research shows it grew higher every year. Online learning and teaching has been increasing in the last two decades. Researches were covering several different topics, such as – learner, course and instructor and organisation (Martin et al., 2020).

A huge amount of online teaching and learning in the past was reserved for higher education as an alternative pathway for adults, wanting to raise their existing education to another level (Lockee, 2021).

That has changed severely in the year 2020, when the COVID-19 pandemic was announced across the world, and people had to stay at home in order to prevent further spread of the virus. With the advantage of digital era's assessment, there was no serious need for the schools to shut down during the lock-down. Schools have quickly adapted to the stay-at-home situation and started organising lessons through online resources. Online education was therefore moved from being reserved for higher education to all educational levels, including early primary schools with pupils as young as 6 years old. With the best solution possible given the situation, also a large amount of new obstacles and challenges came across. Teachers were exposed to new types of lessons, a lot of them had to gain new ICT skills they never thought they would need, pupils were taken away from their peers and had to accept new ways of learning, a lot of time with the help of their parents. At the beginning there was no universal way for schools to face this challenge. Teachers were planning their lessons individually and there were several different techniques and strategies in a framework of a specific school event. With the length of the pandemic also school by school found the way to unify their approach to slowly avoid the confusion and lack of consistency first weeks of wide online teaching and learning caused. Different companies provided different solutions and schools were more than willing to examine and implement the creative ideas that were provided. A lot of schools were using online meeting systems, such as ZOOM and Microsoft Teams and were planning their lessons in MOOC environments (such as MOODLE). As reported in a questionnaire made by OTA, teachers were very creative in searching for different tools for their online lessons (online quizzes platforms, whiteboards, video and audio software …).

Remote learning and teaching has its own needs when planning a lesson. The teacher has to take into account that pupils have limited access to material, that their help and engagement cannot be as present as in live sessions, that pupils' motivation has to be addressed in larger amount, especially when planning a task for pupils' independent engagement.

OTA methodology follows the experiences of teachers who were planning online learning lessons and is also forward-looking in a way, the proposed activities can be implemented as online or face-to-face lessons.

One of the main issues reported during the pandemic was social isolation, when all classes have to be done in an online form. There are several ways to prevent social isolation and feelings of loneliness in general. Social communication via social media and networks, for example. Being connected with others, even if not face-to-face, but the acknowledgement that there are instant responses and that there is a person on "the other site" can have several benefits, including lower depression and anxiety and relationship maintenance (Moore & March, 2022). Therefore, when planning an online lesson, teachers shouldn't avoid such communication between peers, but rather to encourage them. Planning teamwork or working in pairs, for example, encouraging them to use chats, video-calls etc. when giving feedback and to seek help from one another via online social engagement.

SMALL-GROUPS SETTING IN SPECIAL ENVIRONMENTS

By now, small group settings are well established among formal as well as non-formal or informal educational environments. Teachers are encouraged to set small groups within their classes and thus integrate peer learning. Small groups can be very efficient and perform results on high levels. They are enhancing team-working skills, peer communication, inclusion and creative thinking (creative problem solving). In classic "live" lessons, setting small groups has become rather common and has different number of participants: from 2 (also referred as pair) and up to unidentified number, which depends on the needs of whole group or the nature of the given task.

When changing to an on-line environment, setting small groups seemed hardly possible. But several different conference platforms did take care of that. With special option for setting groups via conference platforms, setting small groups was able to continue almost as the lessons were taken in live classrooms. One very important benefit when setting tasks to be taken in small groups when teaching on-line is, beside all above mentioned, is also one step toward preventing the feeling of social isolation. When large groups are led by teachers, social connection is limited even in live lessons. Having those type of lessons in remote classes, the connection falls to a minimum. In teacher-led large groups pupils were asked to turn off their microphones, so the surrounding sound wouldn't distract others, some pupils' cameras didn't work or they didn't have any and the space for their comments and questions was narrowed. With small groups setting, which are enabled by conference platforms, the feeling of inclusion, communication and active participation are increased and improved. Thus, the feeling of social isolation is addressed and for at least some amount improved and this is very important for the times, such as covid-19 pandemic, when people had to stay at homes and not interact with each other at work, school or free time.

2.8 REFERENCES

Anderson, J. R. (1993). Problem solving and learning. American psychologist, 48(1), p. 35. Retrieved from: https://www.ida.liu.se/~729G15/res/kompendium/ACT_R_learning.pdf

Bolte, C., Holbrook, J., & Rauch, F. (2012). Inquiry-based science education in Europe: Reflections from the PROFILES project. Retrieved from: http://phavi.portal.umcs.pl/at/attachments/2014/0702/114749-profiles-book-final-october2012.pdf

Campbell, L., Flageolle, P., Griffith, S., & Wojcik, C. (2002). Resource-based learning. In M. Orey (Ed.), Emerging perspectives on learning, teaching, and technology. Retrieved from: http://epltt.coe.uga.edu/

Colman, A. M. (2015). A Dictionary of Psychology (3 ed.) Oxford: Oxford University Press, p. 308. Retrieved from: https://bit.ly/3NL2IX8

Dunbar, K. (1998). Problem solving. *A companion to cognitive science*, *14*, p. 289-298. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.112.11&rep=rep1&type=pdf

Esch, E. (2002). Resource-based learning. *Guide to good practice for learning and teaching in languages, linguistics and area studies*. Retrieved from: https://www.llas.ac.uk//resources/gpg/2241

Hannafin, M. J., & Hill, J. (2007). Resource-based learning. *Handbook of research on educational communications and technology*, *3*, p. 525-536. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.955.5090&rep=rep1&type=pdf#page=558

Hill, J. R., & Hannafin, M. J. (2001). Teaching and learning in digital environments: The resurgence of resource-based learning. *Educational technology research and development*, *49*(3), p. 37-52. Retrieved from: bf02504914201607l2-22770-5bbip6-with-cover-page-v2.pdf (d1wqtxts1xzle7.cloudfront.net)

Holbrook, J., & Rannikmäe, M. (2007). The nature of science education for enhancing scientific literacy. International Journal of science education, 29(11), p. 1347-1362. Retrieved from: https://hal.archives-ouvertes.fr/hal-00513329/file/PEER_stage2_10.1080%252F09500690601007549.pdf

Holbrook, J., & Rannikmäe, M. (2007). The nature of science education for enhancing scientific literacy. International Journal of science education, 29(11), 1347-1362. Retrieved from: https://hal.archives-ouvertes.fr/hal-00513329/file/PEER_stage2_10.1080%252F09500690601007549.pdf

Holbrook, J., & Rannikmäe, M. (2009). The meaning of scientific literacy. *International Journal of Environmental and Science Education*, *4*(3), p. 275-288. Retrieved from: https://files.eric.ed.gov/fulltext/EJ884397.pdf

Hozjan, U. (2012). Uporaba hevristik pri reševanju problemov in odločanju : magistrsko delo. Univerza v Mariboru, Fakulteta za varnostne vede. Retrieved from: https://dk.um.si/IzpisGradiva.php?lang=slv&id=37949

Kandemir, M. A., & Gür, H. (2009). The use of creative problem solving scenarios in mathematics education: views of some prospective teachers. *Procedia-Social and Behavioral Sciences*, *1*(1), p. 1628-1635. Retrieved from: doi: 10.1016/j.sbspro.2009.01.286

Kolb, D. A. & Kolb A. Y. (2013). *The Kolb learning style inventory*. *4.0: Guide to Theory, Psychometrics, Research & Applications*. Experience Based Learning Systems 2013. Retrieved from: https://www.researchgate.net/publication/303446688_The_Kolb_Learning_Style_Inventory_40_Guide_to_Theory_Psychometrics_Research_Applications

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. New Jersey, Pearson Education, Inc. Upper Saddle River. Retrieved from: https://www.researchgate.net/publication/315793484_Experiential_Learning_Experience_as_the_source_of_Learning_and_Development_Second_Edition

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall. Retrieved from: https://www.researchgate.net/publication/235701029_Experiential_Learning_Experience_As_The_Source_Of_Learning_And_Development

Lockee, B.B. Online education in the post-COVID era. *Nat Electron* 4, p. 5–6 (2021). Retrieved from: https://doi.org/10.1038/s41928-020-00534-0

Martin, F., Sun, T., & Westine, C. D. (2020). A systematic review of research on online teaching and learning from 2009 to 2018. *Computers & education*, *159*, 104009, Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7480742/

Martinez, M. E. (1998). What is problem solving?. *The Phi Delta Kappan*, *79*(8), p. 605-609. Retrieved from: https://www.aapt.org/Conferences/newfaculty/upload/Martinez-Problem-Solving.pdf

Mitchell, W. E., & Kowalik, T. F. (1999). *Creative problem solving*. Retrieved from: https://www.academia.edu/8707593/Creative_Problem_Solving_Mitchell_and_Kowalik

Moore, K. A., & March, E. (2022). Socially connected during COVID-19: online social connections mediate the relationship between loneliness and positive coping strategies. *Journal of Stress, Trauma, Anxiety, and Resilience (J-STAR)*, *1*(1). Retrieved from: https://journal.star-society.org/index.php/j-star/article/download/9/16

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., ... & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational research review*, *14*, p. 47-61. Retrieved from: http://dx.doi.org/10.1016/j.edurev.2015.02.00

Piila, E., Salmi, H., & Thuneberg, H. (2021). Steam-learning to mars: Students' ideas of space research. *Education Sciences*, *11*(3), 122. Retrieved from: https://helda.helsinki.fi/bitstream/handle/10138/329514/PiilaSalmiThunebergMarseducation_11_00122.pdf?sequence=1

Rannikmäe, M., Teppo, M., & Holbrook, J. (2010). Popularity and relevance of science education literacy: Using a context-based approach. Science Education International, 21(2), p. 116-125. Retrieved from: https://files.eric.ed.gov/fulltext/EJ890666.pdf

Roberts, T. G. (2003). *An Interpretation of Dewey's Experiential Learning Theory*. Retrieved from: https://files.eric.ed.gov/fulltext/ED481922.pdf

Sormunen, K., Keinonen, T., & Holbrook, J. (2014). Finnish Science Teachers' Views on the Three Stage Model. *Science Education International*, *25*(2), p. 43-56. Retrieved from: https://files.eric.ed.gov/fulltext/EJ1032965.pdf

Thuneberg, H., Salmi, H., & Fenyvesi, K. (2017). Hands-on math and art exhibition promoting science attitudes and promoting science attitudes. *Education Research International*, *2017*. Retrieved from: https://jyx.jyu.fi/bitstream/handle/123456789/55674/1/fenyvesi9132791.pdf

Yenawine, P. (1997). Thoughts on visual literacy. Originally published in *Handbook of Research on Teaching Literacy through the Communicative and Visual Arts*. Retrieved from: http://vtshome.org/wp-content/uploads/2016/08/12Thoughts-On-Visual-Literacy.pdf

Online sources:

https://asq.org/quality-resources/problem-solving

www.profiles-project.eu

Picture sources:

Own

Rannikmäe, M., Teppo, M., & Holbrook, J. (2010). Popularity and relevance of science education literacy: Using a context-based approach. Science Education International, 21(2), p. 120. Retrieved from: https://files.eric.ed.gov/fulltext/EJ890666.pdf

CHAPTER 2: LITERATURE REVIEW

1 INTRODUCTION

When planning & delivering science lessons in a classroom setting or an online/ blended mode, it is important that science teachers are provided with a specific methodology to follow, in order to effectively involve their students in the learning process, stimulate their motivation and interest and achieve the expected outcome. By investigating and identifying challenging issues and best practices related to online or offline teaching & learning of science, the educational community can modify and support effective strategies. In this context, the current report, prepared under a two-year Erasmus+ project called "OTA – Online Teaching Advancement: Science Through Art" explores the state-of-the-art in online or offline teaching & learning of science (Math, Chemistry, Physics) in primary and secondary schools at a national & European level. It unveils the main challenges that emerge during the delivery of offline or online science lessons and the effectiveness of the practices, methods, and approaches followed up to now. The study is directed by the following research questions:

a) What kind of challenges teachers face when teaching science in a classroom setting? In what different social contexts these challenges are occurring?
b) Are they related to the specific social context that the OTA project investigates (namely the emergency of online teaching & learning due to Covid-19 pandemic and its impact on teachers and students)?
c) Do these challenges differ from country to country? Do they correlate with the needs analysis conducted as part of the OTA Project – IO1?

Through a systematic literature review, the research team provides answers to the above questions, forming a coherent pedagogical framework. As a result, the project's consortium will be better prepared to design appropriate material, resources, guidelines, and recommendations that will respond to the needs of primary and secondary science teachers, in order to effectively teach their subjects online or offline with the use of art as a tool to combat main challenges such as demotivation, lack of interest and isolation.

2 METHODOLOGY

We conducted a Systematic Literature Review (SLR) to examine the state-of-the-art of online or offline teaching of science at primary and secondary schools on the national and the European level. For research purposes, we accessed e-databases and examined various articles. The keywords used for the research were the following: *online teaching, online learning, distance education, science education, challenges of science teachers, science in schools, Covid-19.* To limit the results and choose the appropriate studies, we applied the following inclusion criteria:

- The articles should be published between 2010-2022.
- The articles should be published in journals and/or proceedings (In case of Slovenia also a handbook for teachers was considered, because it is relevant for the topic).

Based on the above criteria, we gathered the appropriate articles related to the topic and concluded the following findings.

3 FINDINGS AND DISCUSSION

3.1 CHALLENGES IN A CLASSROOM SETTING

According to research, teaching science in a classroom setting can be quite challenging. When planning a face to face lesson, science teachers have to take into consideration different factors that might affect the quality of the teaching and learning process, the students' interest and motivation and the level of achieving the expected learning outcomes. These factors include the time limit, the laboratory equipment & material, the use of appropriate teaching methods, the students' level of engagement & motivation in class.

The time limit in relation to the overburdened curriculum that needs to be covered is one of the main challenges mentioned by researchers and teachers themselves (see Chapter 3.3 OTA needs analysis & Kubilay et al., 2012). Science lessons require much more teaching time than other theoretical subjects, as they usually imply a combination of the theoretical part with hands-on activities, experimentation and teamwork. Teachers are not given the time needed to effectively interact with their students or promote investigation, experimentation, collaboration and peer learning. Teachers also need extra time before the delivery of the lesson to prepare the necessary tools or resources and after the lesson to tidy-up everything.

When preparing a lesson plan, science teachers also need to consider the use of laboratory equipment, material or ICT tools. Sometimes the lack of classroom resources or inadequate infrastructure does not allow teachers to incorporate a hands-on approach or technology in their lessons, as reported in desk research of the EU project IN2STEAM (also Seals et al., 2017). This issue worsens due to the high number of students in the class. One teacher usually needs to support and find enough resources to cover the needs of 20 to 25 students.

The scarce use of innovative methodology or technology in class is also due to the lack of motivation among teachers. The traditional education followed at least in the schools of Cyprus promotes a conventional learning approach, which relies on repetition and memorization of information concluding in a written or oral evaluation.

During the learning process, teachers' aim is to cover the intensive school curriculum and learners are mainly active listeners to the educator's lesson. Even science teaching remains a telling instruction rather than doing (Jacobson 2010). In Slovenia in 2014 an extended upgrade for teaching natural subjects was written with didactic materials and examples for learning lessons which is promoting the use of hands-on activities and experiential learning. Authors are focusing mainly on chemistry, biology and physics and are emphasising an active role of pupils during the lesson. They are encouraging teachers to switch from traditional education to more contemporary and pupil-centred (Moravec et al., 2014). This shows that there are tendencies to encourage Slovenian teachers to adopt more contemporary approaches and methods but it also shows the awareness of the presence of more traditional teaching and that there are guidelines needed to introduce new approaches and possibilities to teachers. In Italy the separation between humanities and science remains significantly stronger than elsewhere: there is a high humanistic tradition and the scientific subjects are perceived as a world separate from the rest of the educational curriculum. While the humanities are generally felt to be part of widespread general culture, the scientific disciplines are often seen as a subject reserved for insiders (Vincenzo Smaldore, 2022). The challenge is to contaminate interdisciplinary approaches, developing a teaching method that enhances, alongside the analytical rigour of science, the creativity and curiosity of students. In the Italian pedagogical field, this has led to an idea of secondary schooling whereby laboratories are not fully accredited as places where discipline is manifested. It is the lectio that prevails; the word prevails over experience, over procedure. Doing, problem solving, governing processes is secondary to the word (Marco Rossi-Doria, 2022).

Of course, most teachers also lack experience and skills in teaching with innovative methodology or technology. Some teachers at all grade levels do not feel confident teaching some of the science material they are expected to cover (Viadero et al., 2021). Most teachers are not familiar with the appropriate pedagogical framework of teaching science (creative problem solving, hands-on learning, resource-based learning, experiential learning, the connection of a problem or phenomenon to students' lives). They do not use inquiry-based teaching approaches in their classrooms to engage students in real-world experiences. (Crawford 2012). A core element of teaching science is the "learning by doing principle": placing students at the heart of learning, giving them the opportunity to experiment by themselves via hands-on methods, make observations, connect phenomena with the social environment and discover creative solutions (Salmi et al., 2020). Science teachers need training on these methods (Crawford, 2012; Anderman et al., 2012).

Teachers are also not so familiar with combining science with other subjects that might help students use their prior knowledge and better understand phenomena. Teachers need to develop both skills and attitudes toward interdisciplinary teaching (Al Salami et al., 2017). They need to start using ICT tools and technology or out-of-classroom settings to make the knowledge more interesting and tangible. Science teachers tend to ignore that experiences outside school, such as visits to science museums, hands-on centres, galleries, botanical gardens or working in nature can influence students' attitudes, motivation to learn and effectiveness (Kubilay et al., 2012). An exception to this is Finland, for example, where the official school curriculum gives freedom to teachers to utilise informal learning settings (Salmi et al., 2020).

This inability or reluctance in using innovative teaching approaches, ICT tools or informal settings seems to be the reason why maintaining students' interest for science is challenging even in regular times, before the pandemic crisis (Rannastu-Avalos et al., 2020). The traditional teaching approaches are not even effective for teaching Physics, Chemistry or Maths. These subjects need student-centred approaches, hands-on activities, investigation & experimentation, and even small group-working. This is why teachers usually face classroom management issues & interruptions (Seals et al., 2017). They are unable to stimulate students' excitement and motivation to participate in the lesson (Seals et al., 2017) and can hardly promote and develop the 21st-century skills required to raise active and critical citizens of tomorrow (such as communication, teamwork, creative thinking and problem solving). The current guidelines at least in Cyprus enable little or no flexibility in implementing innovative approaches (such as inquiry-based learning), since the main aim is to cover the school curriculum and succeed in the final examination, instead of developing holistic personalities.

3.2 CHALLENGES IN AN ONLINE OR BLENDED SETTING

The OTA project seeks to go beyond the classroom setting and investigate the main challenges of teaching science subjects in a specific social context: the remote teaching & learning processes, which were adapted due to the outbreak of the Covid-19 pandemic in all European school systems. What was previously done face-to-face has been transferred online or even in a blended mode. This new way of teaching and learning seems to have highlighted and even intensified the already existing challenges the teachers face in a classroom setting. It also resulted in new ones, such as the lack of socialisation.

No educational system seems ready to go completely online, especially the Cypriot one which has been entirely based on face to face learning (Nisiforou et al., 2021). Online education highlighted the already existing issues of time limit, inadequate infrastructure in schools, low digital literacy and lack of digital readiness of students and teachers, limited internet access and lack of online laboratory environments (Sofianidis et al., 2021 & Katić et al., 2021).

Time limit is even more challenging in online or blended education. When schools closed due to the pandemic, science took a particularly hard hit, as schools focused on the basics (Viadero D., et al., 2021). Only a limited amount of time was allocated to science subjects online (as discussed in Chapter 3.3: for example, chemistry teachers in Cyprus reported they were teaching just an hour per week online) and it was quite hard for science teachers to effectively deliver their lessons within the time available, having to cover the overburdened curriculum and combine theory with practice at the same time. Much more time, effort and planning was/ is required to prepare an online or blended lesson, which for teachers is considered more tiring than a class lesson (Nisiforou et al., 2021 & & Katić et al., 2021).

The online education also made a more student-centred instruction even harder. Teachers can hardly implement more student-centred activities online, such as applying knowledge in practice tasks, organising peer review or using collaborative learning. Remote learning made hands-on scientific inquiry even more difficult to do (Viadero et al., 2021). In the case of Cyprus, teachers rarely tried to include new practices and tools suitable for distance learning settings, such as videos, quizzes, online discussion forums, breakout rooms, games, virtual laboratories, simulations (Sofianidis et al., 2021). Research made in Slovenia by the National Education Institute of Slovenia in 2020 shows that teachers did use different methods, though there are two methods standing out: platforms for live conferences and written instructions (Zavod Republike Slovenije za Šolstvo, 2020). With regard to Italy, before the Covid-19 tsunami, Italian schools had not yet introduced digital technology in a widespread and conscious manner as a tool for enhancing the learning and citizenship skills of their students. Teachers, in fact, have been using different digital tools and materials, often without having the necessary skills (Paolo Maria Ferri, 2020).

This delicate historical period, allows Italian teachers to approach diversified methodologies and appreciate the support that the use of digital technology can give to teaching.

Online learning has also clear benefits:

• Easier to implement multimodal approaches: The combination of audio, video, text, and other means to convey meaning has the potential to provide students greater access to curricula and learning opportunities and additional ways to demonstrate their understanding (Hashey & Stahl, 2014)

• Easier to implement differentiation (at individual level or sub-group level): Teachers can customize the focus of instruction to best meet students' unique learning needs (Hashey & Stahl, 2014)

• Individual pace of learning: students can work at their own pace and work at a time of day that suits the student.

• Lack of distractions: During online learning students may benefit from fewer distractions by peers or by noise in the classrooms and it may be easier to control and manipulate distractions in the home.

• Better meaningful social contact: some students have been show to benefit from online social interactions which are often perceived as being less threatening

• Students with disabilities themselves are motivated and perceive that they can learn online (Harvey et al., 2014)

In Finland best practices show that very simple top tips, made for online teaching for pupils with special needs, can be useful to help all teachers and parents to fully access online teaching materials and lessons. Top tips like checklists of tools, providing clear rules, asking personal questions of the learning experience, allowing regular breaks, sharing lesson plans with the parents, etc. can brake barriers and facilitating factors (Guidance for the inclusion, 2022).

Implementing such activities or using appropriate tools and methods online requires specific pedagogical, content- and technological knowledge and skills. Due to the lack of experience with online pedagogy and digital educational material and tools, teachers struggled and still are unable to shift their daily teaching practices into online or blended mode to meet the complexities of remote teaching (Nisiforou et al., 2021; Junsay et al., 2021; Sofianidis et al., 2021 & Katić et al., 2021).

The difficulty of adapting the material & applying an online pedagogy resulted in lack of interaction in distance education. This was another challenge that affected students' well-being and their socio-emotional needs, as research reports for the case of many EU countries, such as Cyprus, Italy and Slovenia (Nisiforou et al., 2021; OECD, 2020 & Katić et al., 2021). Students seem to find it hard to concentrate online, even interact or collaborate with their teachers and classmates. Especially in science, which is a content – oriented subject, this lack of interaction and collaboration among students can be a serious barrier, as it demotivates learning and increases boredom (Junsay et al., 2021; Sofianidis et al., 2021; Rannastu-Avalos et al., 2020).

A study investigating secondary education students' experiences on the distance education period that followed schools' closure due to the pandemic in Cyprus shows that the lack of visual contact of students with classmates and teachers or the inability to participate in out-of-the classroom activities resulted in feelings of isolation, disconnection and boredom. This is not only the case in Cyprus. Studies conducted in other countries during the pandemic have also indicated significant increases in students' emotional/psychological distress and a decline in their wellbeing during school closure. Students did not find remote learning a satisfactory learning experience. It seriously affected their engagement, productivity and performance. Such losses were greater in Mathematics than in reading (Sofianidis et al., 2021 &

Amoah et al., 2020). This is what the teachers themselves also reported in all partner countries as a main issue in online education (discussed in Chapter 3.3).

Based on the above, we can safely conclude that teachers need preparation & training not only in the technicalities of online teaching. Training in new pedagogical practices and tools related to distance learning and the use of virtual experimentation is necessary, especially for STEM courses that require different types of interaction, often including experimentation, group work and participation in inquiry-based activities (Evagorou et al., 2020). Teachers need to develop virtual strategies, use a combination of audio, video and text for promoting teacher-students' communication, peer interaction and collaboration, real-time engagement, in this way providing a sense of community and a human touch to their lessons (Sofianidis et al., 2021; Devitt et al., 2020). The lack of social interaction should be filled with education toward emotion (Katić et al., 2021) that can be promoted via art and the aesthetic elements of handicraft.

The curricula should be reviewed and adapted to accommodate the needs of distance education, the assessment practices should be modified and new technologies must be incorporated to offer the teachers new options which are online friendly. Cooperation between teachers should be promoted to support each other and exchange practices. The pandemic and the consequent shift to the online education is an opportunity for teachers to enrich the media they are using to represent learning (Nisiforou et al., 2021; Sofianidis et al., 2021 & Devitt et al., 2020).

3.3 COUNTRY-WISE COMPARISON. THE OTA NEEDS ANALYSIS (IO1)

At this point, it could be useful to compare the above literature review, which mostly covers the national, but also the European context, with the report on the learning needs of target groups, developed as part of the IO1 of the OTA project. This report includes the experiences, challenges and needs of science teachers from Cyprus, Finland, Slovenia and Italy, particularly in regards to online teaching and learning, as shared via an online questionnaire and national focus groups.

This needs analysis highlighted some major challenges of teachers and pupils in online education, also identified in the literature review. One of them is the time limit. Teachers from all countries seem to struggle with time management, when teaching online. They all mentioned the excessively broad nature of national curricula and the huge workload needed, which does not allow them to combine theory with practice, to be more autonomous, innovative, creative and really try to invest in their pupils' experiences and skills within the short time slots.

The majority of teachers from all countries reported a high improvement of their digital skills due to the emergency of remote teaching, while most Cypriot and Finnish teachers mentioned an already high level of ICT skills even before the pandemic started. However, based on the findings of this same report and the above literature review, we can assume that these improved skills might only refer to the technicalities of online teaching: connecting to the internet, handling internet issues, using mostly platforms (such as Zoom or Teams) to deliver the lesson. All teachers have indeed reported using some digital tools to improve interaction (mostly platforms and shared documents), apart from the case of Finnish teachers who reported a limited use of tools. However, the literature review shows a limited use of interactive tools suitable for distance learning settings, such as videos, quizzes, online discussion forums, breakout rooms, games, virtual laboratories, simulations (this is especially the case for Cyprus). All teachers in the report admit that they need more training in digital technologies and more digital tools options. In terms of teachers' ICT skills in Slovenia, according to research of National Education Institute of Slovenia from 2020 the majority of teachers is quite confident in independent usage of different digital tools, except when it comes to shooting and sharing an on-line courses (Zavod Republike Slovenije za Šolstvo, 2020).

As for students' concentration, motivation and interaction in online science lessons, most teachers in Slovenia, Cyprus, Italy and Finland agree with what the literature review reveals: a medium to low level of concentration online (lower than in class) and lack of interaction. This is due to the fact that the cameras were off and there was a lack of visual contact with the teacher and other classmates. Surprisingly, half of the teachers in Slovenia and Italy rated the interaction online as good, while Cypriot & Finnish teachers reported a lack of interaction that affected the learning motivation. This is a serious issue also mentioned in the literature review: the limited use of interactive digital tools resulted in lack of interaction, loss of interest & motivation of students.

It is also worth mentioning that the majority of Slovenian, Cypriot and Italian teachers have never used an interdisciplinary/STEAM approach, namely to combine their subject to other subjects, possibly art. Italian teachers mentioned that they tried this approach online and students found the connections easy. All teachers recognize that this approach can make their lessons more interesting for students. Only Finnish teachers are more familiar with the interdisciplinary approach. An important factor for the success of this approach is, according to Finnish and Italian teachers, the good collaboration between teachers. This data agrees with the literature review that stresses the need for developing the skills and attitudes of teachers toward interdisciplinary teaching.

Last but not least, in spite of the challenges of online education and the fact that it overturned the relationship between teacher-didactics, teacher-pupil and pupil-school and revealed a system quite "traditional" that does not keep up with the times, most teachers, especially in Cyprus and Italy, agree that online learning provided them with new possibilities and new ways of teaching. Teachers can prepare guidelines in advance and pupils can implement and repeat the experiments on their own, gaining more autonomy and freedom. Distance learning was an example of how, with a bit of creativity it could be possible to innovate and enrich the teachers' modus operandi. This is a positive aspect also highlighted in Chapter 3.2.

Teachers might not be so familiar with innovative methodology, such as the STEAM method or the digitization of teaching yet, (as already proved by researchers in Chapter 3.2 and the OTA needs analysis) but they are open to new ideas and new material. They are ready to embrace innovation, and be more flexible when teaching science, but they need easy-to-use tools, training and a STEAM framework to follow.

4 CONCLUSION AND FINAL REMARKS

The OTA needs analysis (IO1) together with the literature review reveal the need for an intervention that can help the target groups improve their skills and competences, leading to a more effective and smooth offline, but mostly online, teaching & learning of science. Only a well-educated teacher can create an appropriate environment for students to learn science, while also developing competencies needed for the 21st century, such as problem-solving and creative thinking.

The OTA project seeks to exactly act as this kind of intervention. By providing an open learning methodology and the necessary implementation tools, it aims to support science teachers teach their subjects, with the use of arts and creativity, in this way, helping their pupils to enhance their wellbeing and learning results in science and overcome barriers due to the ongoing Covid-19 pandemic.

It is well proved from research that the additional integration of Art as a skill (STEAM) in the education of science, technology, engineering and mathematics (STEM) can support and improve traditional education in Europe and globally. The aesthetic elements of handicraft and art promote understanding of scientific and more abstract concepts by exposing students to concrete space and shape experiences (Salmi et al., 2020).

This is the real-time engagement and experience students need, especially now after the lack of interaction & socialisation that the pandemic and subsequent online education imposed. Research should investigate best practices to facilitate the online learning experience, integrating more interactive activities (Katić et al., 2021.) This is what the OTA project seeks to do, using Art as a powerful tool.

5 LITERATURE

Al Salami, M.K., Makela, C.J. & de Miranda, M.A. (2017). Assessing changes in teachers' attitudes toward interdisciplinary STEM teaching. *Int J Technol Des Educ 27*, 63–88. Retrieved from: https://doi.org/10.1007/s10798-015-9341-0

Amoah, C.A.; Naah, A.M. (2020) Pre-Service Teachers' Perception of Online Teaching and Learning during the COVID-19 Era. Int. J. Sci. Res. Manag 8, 1649–1662.

Anderman E.M., Gale M. Sinatra & DeLeon L. Gray (2012). The challenges of teaching and learning about science in the twenty-first century: exploring the abilities and constraints of adolescent learners, Retrieved from: https://doi.org/10.1080/03057267.2012.655038

Crawford B.A. (2012). Moving the Essence of Inquiry into the Classroom: Engaging Teachers and Students in Authentic Science. Tan K., Kim M. (eds) *Issues and Challenges in Science Education Research.* Springer, Dordrechtz

Devitt, A.; Bray, A.; Banks, J.; Ni Chorcora, E. (2020). Teaching and Learning during School Closures: Lessons Learned. Irish SecondLevel Teacher Perspectives. Trinity Dublin. Retrieved from: http://www.tara.tcd.ie/handle/2262/92883

Marco Rossi-Doria, 2022. STEM, una sfida per la scuola italiana. Retrieved from: https://www.focus-scuola.it/2022/01/07/stem-una-sfida-per-la-scuola-italiana/

Evagorou, M. & Nisiforou, E. (2020). Engaging Pre-service Teachers in an Online STEM Fair during COVID-19. Journal of Technology and Teacher Education, 28(2), 179-186. Waynesville, NC USA: Society for Information Technology & Teacher Education. Retrieved from: https://www.learntechlib.org/primary/p/216234/.

Paolo Maria Ferri, 2020. Formare i docenti alle tecnologie didattiche per il nuovo anno: le sfide. Retrieved from: https://www.agendadigitale.eu/scuola-digitale/scuola-aumentata-formare-i-docenti-alle-tecnologie-didattiche-per-il-nuovo-anno-le-sfide/.

Guidance for the inclusion of students with Special Educational Needs for online learning. Earli SIG 15. Special Educational Needs. Guidance for the inclusion of students with Special Educational Needs for online learning. Retrieved from: https://earli.org/sites/default/files/2020-10/EARLI%20guidelines_COVID%20online%20inclusion_0.pdf

Harvey, D., Greer, D., Basham, J., & Hu, B. (2014). From the student perspective: Experiences of middle and high School students in online learning. American Journal of Distance Education, 28(1), 14–26.

Hashey A., & Stahl S. (2014). Making online learning accessible for students with disabilities. Teaching Exceptional Students, 46(5), 70-78. Retrieved from: doi:10.1177/0040059914528329

Jacobson N. (2010). Re-visiting Secondary School Science Teachers Motivation Strategies to face the Challenges in the 21st Century, *Academic Leadership: The Online Journal:* Vol. 8 : Iss. 4, Article 54.

Retrieved from: https://scholars.fhsu.edu/alj/vol8/iss4/54

Junsay FB Jr, Madrigal DV. (2021). Challenges and Benefits of Facilitating Online Learning in Time of Covid-19 Pandemic: Insights and Experiences of Social Science Teachers. *Technium Social Sciences Journal* 20:233-243.

Katić, S., Ferraro V. F., Ambra. F.I., and Lavarone M. L. (2021). Distance Learning during the COVID-19 Pandemic. A Comparison between European Countries, *Education Sciences* 11, no. 10: 595. Retrieved from: https://doi.org/10.3390/educsci11100595

Kubilay K., Ozden T., (2012). Challenges for Science Education, Procedia - Social and Behavioral Sciences Volume 51, Pages 763-771. Retrieved from: https://doi.org/10.1016/j.sbspro.2012.08.237

Moravec B. et al., (2014). Posodobitve pouka v osnovni šoli. Naravoslovje. Retrieved from: https://www.zrss.si/pdf/pos-pouka-os-naravoslovje.pdf

Nisiforou EA, Kosmas P, Vrasidas C. (2021). Emergency Remote Teaching during COVID-19 Pandemic: Lessons Learned from Cyprus. Educational Media International 58(2):215-221. Retrieved from: https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,sso&db=eric&AN=EJ1313207&site=eds-live

OECD. (2020). OECD policy responses to coronavirus (COVID-19): Combatting COVID-19's effect on children", Tackling Coronavirus (Covid-19): Contributing to a global effort. Retrieved from: http://www.oecd.org/coronavirus/policy-responses/combatting-covid-19-s-effect-on-children-2e1f3b2f/ [Google Scholar]

Rannastu-Avalos M., Siiman L.A. (2020). Challenges for Distance Learning and Online Collaboration in the Time of COVID-19: Interviews with Science Teachers. In: Nolte A., Alvarez C., Hishiyama R., Chounta IA., Rodríguez-Triana M., Inoue T. (eds) *Collaboration Technologies and Social Computing.* CollabTech 2020. Lecture Notes in Computer Science, vol 12324. Springer, Cham. Retrieved from: https://doi.org/10.1007/978-3-030-58157-2_9

Salmi, H., Thuneberg, H. & Bogner, F. X. (2020). Is there deep learning on Mars? STEAM education in an inquiry-based out-of-school setting. In: *Interactive Learning Environments.*

Seals C., Mehta S., Berzina-Pitcher I., Graves-Wolf L. (2017). Enhancing Teacher Efficacy for Urban STEM Teachers Facing Challenges to Their Teaching, *Journal of Urban Learning, Teaching, and Research,* v13 p135-146. Retrieved from https://eric.ed.gov/?id=EJ1150083

Vincenzo Smaldore, (2022). STEM, una sfida per la scuola italiana. Retrieved from: https://www.focus-scuola.it/2022/01/07/stem-una-sfida-per-la-scuola-italiana/

Sofianidis A, Meletiou-Mavrotheris M, Konstantinou P, Stylianidou N, Katzis K. (2021). Let Students Talk about Emergency Remote Teaching Experience: Secondary Students' Perceptions on Their Experience during the COVID-19 Pandemic. *Education Sciences*.11. Retrieved from: https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,sso&db=eric&AN=EJ1300849&site=eds-live

Viadero D, Sparks SD. (2021). 6 Challenges for Science Educators. *Education Week. 41(14):3-5.* Retrieved from: https://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,sso&db=f5h&AN=153772768&site=eds-live

Zavod Republike Slovenije za šolstvo. (2022). Izobraževanje na daljavo v času epidemije Covid-19 v Sloveniji. Retrieved from: https://www.zrss.si/novice/izobrazevanje-na-daljavo-v-casu-epidemije-covid-19-v-sloveniji/

CHAPTER 3: EXAMPLES, GOOD PRACTICES AND INSPIRATIONAL MATERIAL

1 INTRODUCTION

In the following chapter we are presenting concrete activities which are material linked to the OTA Methodology. The material is presenting good practices from partners' institutions, examples of how activity should be implemented to follow OTA Methodology and/or inspirational material, coming from experiences and actual work of our OTA project partners.

Elementary School of Litija and INNOVADE thus provided examples on how chosen activity can be implemented to follow OTA Methodology. National Gallery of Slovenia and HEUREKA presented good practices from their pedagogical work. Activities are closely connected to OTA Methodology and are following some of the core principles emphasised in the methodology. Those materials should serve as a priceless inspiration for wider educational work to all interested parties.

2 PRIMARY SCHOOL OF LITIJA

SUBJECT	Chemistry
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Chemical reactions
LEARNING OBJECTIVES	• Understand chemical changes as chemical reactions or as material and energy changes, • identify the reactants and products of the chemical reaction, • understand that chemical reactions are subject to the law of conservation of mass, • know chemical equations as records of chemical reactions and know the rules for regulating chemical equations. Use an experimental research approach or laboratory skills in the study of chemical reactions and deepen knowledge in the field of chemical safety (safe work with chemicals).
ART EXPRESSIOSIONS/VISUAL FORMS USED	Protection of more valuable works of art from fire, extinguishing works of art with as little damage as possible (without dust and water).
SPECIAL REQUIREMENTS	Vinegar, baking soda, protective equipment, glass, lighter, candle, dosing and mixing spoon.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Fire extinguisher.
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	How to put out a fire with as little damage to the object as possible? Understand that fire requires fuel, high enough temperature and oxygen, and that without one of these three fires there is none.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Production of a device that works on the basis of a CO2 fire extinguisher and demonstration of operation on a burning candle.
TASKS	Model making: Vinegar (Ethanoic acid CH_3COOH) is mixed with baking soda (sodium bicarbonate $NaHCO_3$) to obtain gas 2 carbon dioxide (CO_2), 2 water (H_2O) and salt (sodium acetate CH_3COONa) $CH_3COOH + NaHCO_3 = 2CO_2 + 2H_2O +$ CH_3COONa

	When the reaction calms down and the foamy bubbles burst, the CO_2 "lies" in the glass, as it is heavier than air.
GOAL OF TASKS	After the reaction is complete, "pour" CO_2 over the burning candle and the candle goes out. At the same time, do not pour any water over the candle.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Experiential learning
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion.
EXPECTED RESULTS	To know that every chemical reaction is a material and energetic change, to be able to describe simple chemical reactions in words and to identify reactants and products in cases of simple chemical reactions.
ASSESSMENT	
EVALUATION	Description of the chemical reaction in your own words.

OŠ Litija

SUBJECT	Physics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	DENSITY, PRESSURE AND LIFT Density and specific gravity
LEARNING OBJECTIVES	• They know what homogeneous bodies are, • separate homogeneous bodies from inhomogeneous ones, • the difference between substances of different densities, • by comparing densities or average densities, explain under which circumstances, the body floats, swim or sinks. Experimentally investigate buoyancy (E).
ART EXPRESSIOSIONS/VISUAL FORMS USED	Lava light
SPECIAL REQUIREMENTS	Substances and accessories: - edible oil, - water, - magnesium effervescent tablets, - food colouring, - glass flasks, - pumpkin stand.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Oil and water
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	Oil spill in an accident. Why does oil float on water?
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Demonstration of the difference in density of water and oil. Effervescent tablets contain magnesium carbonate, citric acid… The reaction between magnesium carbonate and water results in the formation of carbon dioxide, which rises in the form of bubbles towards the surface of the flask. Water and oil do not mix. The oil has a lower density and therefore floats on water. Carbon dioxide rises in bubbles towards the surface and carries the dye with it.

TASKS	Manufacture of Lava lights Pour a little colored water into the flask attached to the stand. Add oil that is more than water. Add effervescent tablets. Quantities are not determined, in the experiment the student determines the quantities on the basis of experiments.
GOAL OF TASKS	Lava light - display of oil floating on water. Water and oil do not mix. No matter how much we shake the dish, water and oil do not mix with each other. Low-density oil floats on water. The dyes themselves and the use of the magnesium tablet are exclusively for aesthetic appearance. Effervescent tablets contain magnesium carbonate. As a result, water and magnesium carbonate react and bubbles are released. (cross-curricular link with chemistry).
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Creative problem solving, pair work, independent work, research, experiential learning.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion
EXPECTED RESULTS	Know the difference in density of matter. Know why homogeneous matter floats.
ASSESSMENT	
EVALUATION	Description of buoyancy and swimming in your own words, knowledge and differentiation of homogeneous or heterogeneous substances.

OŠ Litija

SUBJECT	Mathematics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	GEOMETRY AND MEASUREMENT Geometric elements
LEARNING OBJECTIVES	Different types of angles: concave / convex, solid angle, zero angle, elongated angle, sharp angle, obtuse angle, right angle, draw angles and describe the size of individual types of angles.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Drawing / constructing a right angle with the help of a string.
SPECIAL REQUIREMENTS	Rope, sticks.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Right angle.
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	Paths between flowerbeds, how to design parallel and rectangular paths between flowerbeds.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Making parallel paths between the beams using a right angle to one of the sides of the beam.
TASKS	Using a string and a stick, draw a right angle (like drawing with a compass and a ruler), measuring distances on one side of the beam, drawing parallels. The distances between the paths are measured on the side of the beam. Using a string and a stick on the principle of drawing rectangles with a compass (string - compass) draw the measured distances of the rectangle.
GOAL OF TASKS	Drawn parallels, rectangles and made paths.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Creative problem solving, pair work, independent work, research, experiential learning.
CONSOLIDATION STAGE	

APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion
EXPECTED RESULTS	Knowledge of constructing geometric elements with the help of compasses and rulers, knowledge of angles, application of knowledge on a practical example.
ASSESSMENT	
EVALUATION	Checking the understanding of what is parallel and what is perpendicular, checking the knowledge of constructing parallels and rectangles.

OŠ Litija

SUBJECT	Physics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	LIGHT Refraction of light beam
LEARNING OBJECTIVES	They understand that the angle of a light beam is refracted when passing between different substances.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Refraction of light through thick glass, glass run-off in old windows and increase in thickness at the bottom of the window and thus an even more pronounced refraction of light.
SPECIAL REQUIREMENTS	Container with opaque sides, coin, water
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Refraction of light in water.
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	Why are my feet in the water bigger than they really are?
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	How to see a coin that is behind the edge of a container.
TASKS	Place the coin in the container at the far edge. Tilt so that the wall of the container will just overlap the coin. Add water. While refilling, you notice that the coin is "showing up" and in the end you can see the whole coin. Due to the physical phenomenon, the refraction of light, the speed of light changes when passing into another substance. This also changes the direction of the light beam.
GOAL OF TASKS	See the coin behind the edge of the container.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Creative problem solving, experiential learning.
CONSOLIDATION STAGE	

APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion.
EXPECTED RESULTS	Knowledge of the laws of refraction of light, know how to draw the path of a light beam when passing between substances, know how to find the refraction of light in nature.
ASSESSMENT	
EVALUATION	Draw and describe the path of the beam.

OŠ Litija

IC GEOSS
Narodna galerija National Gallery of Slovenia
Heureka
cesie the world is only one creature
innovade LEADERSHIP IN INNOVATION
LITIJA

SUBJECT	Mathematics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	GEOMETRY AND MEASUREMENT Geometric concepts
LEARNING OBJECTIVES	Get to know and use Thales' theorem.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Measuring the height of the Piran bell tower.
SPECIAL REQUIREMENTS	A stick of known height, a metre, a sunny day.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Measuring height with Tales theorem (ratios / proportions).
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	How to measure the height of a tall object with simple tools.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Bell tower height measurement.
TASKS	By measuring the length of the shadow bars and the bell tower and calculating the length ratios, the height of the bell tower is calculated as the ratio of the height of the bar and the bell tower. First, the length of the shadow of the rod and the bell tower is measured and their ratio is calculated. The resulting ratio is used in calculating the height relative to the length of the rod.
GOAL OF TASKS	Calculated (measured) height of the bell tower.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Creative problem solving, pair work, independent work, research, experiential learning.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion.

EXPECTED RESULTS	Knowledge of Tales' theorem and consequent. Knowledge of the relations of the sides between in similar triangles.
ASSESSMENT	
EVALUATION	Checking the understanding of how the relationships between the sides are related in similar triangles.

OŠ Litija

3 NATIONAL GALLERY OF SLOVENIA

SUBJECT	Art class, physics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Types of light
LEARNING OBJECTIVES	To learn about different types of illuminance with specific wavelengths, providing information not discernible in visible light (UVF methods (ultraviolet fluorescence), IRF (infrared photography) and IRR (infrared reflectography)).
ART EXPRESSIOSIONS/VISUAL FORMS USED	Direct: using different types of illuminance to see what's beneath the top layers of the painting.
SPECIAL REQUIREMENTS	Cooperation with our Department of Conservation and Restoration; use of UV and infrared light.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Visiting the Conservators-Restorers - what is hidden from our eyes? *Guided tour and workshop for Gal's Children Club.*
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	Issue: - Do we always see everything that had been painted or is there something hidden from our eyes? - How can we investigate, if there is something painted beneath the top layers of the paint? - Can we learn something from the research; for e.g. about the artist, about his methods of work, about the way of how the works of art were made in the past etc.?
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	**Part one:** We talk about: Why it is important to take care of the works of art?

	How we take care of the artworks; the right climate conditions, light intensity, no-touch and non-invasive approach? **Part two:** We go around our permanent collection and look at the visible injuries, we talk about how we/they think the injuries occurred. **Part three:** We visit the Gallery's Conservation-Restoration Department and take a look at selected works of art, also illuminated with specific light's wavelengths, to see underneath the paint layer. We learn what individual type of illumination reveals to our eyes and in what ways can we use it. **Part four:** Conservators-restorers teach the children, how they repair or conserve the works of art. We make a group photo under the UV lights.
TASKS	Children have to answer some questions: - What can we see under the visible light/ UV light/ IR light? - What can we do with this knowledge? - What can we do to preserve works of art? - How do we preserve the works of art?
GOAL OF TASKS	To learn that art and science are connected, intertwined. We can use physics and chemistry to better understand the artworks, painters and methods of work in different periods of time.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Experiential learning, teamwork.

CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion.
EXPECTED RESULTS	Children understand the practical applications of scientific methods.
ASSESSMENT	Museum educator and conservation-restoration specialist talk about the visit.
EVALUATION	Lesson is very effective, children are fascinated and remember the facts learned long afterwards.

Source: National Gallery of Slovenia

SUBJECT	Art class, chemistry
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Pigment, binder, solvent
LEARNING OBJECTIVES	To learn: - about different types of paints and painting materials, - how to make your own paint (tempera).
ART EXPRESSIOSIONS/VISUAL FORMS USED	Direct use and analysis.
SPECIAL REQUIREMENTS	No special requirements.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Make your own paint. *Guided tour and workshop for Gal's Children Club (Children aged 6–12).*
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	How did painters make their own paint in the past? Can we do the same?
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	**Part one:** We talk about: - what is paint, what do we use it for? - what kind of paints do we know (tempera, oil paint, pastel …) and what are the differences between them? - what do we need to make our own paint? **Part two:**

	- we go around our permanent collection and look at the works of art, made or coloured with different kinds of paints. **Part three:** - we make our own egg tempera, - we paint a scene of our choosing with our new paint.
TASKS	Children have to answer some questions: - What is paint? - What kind of paints do we know (tempera, oil paint, pastel …)? - What are the differences between them? - What do we need to make our own paint? Children observe the works of art in the permanent collection and try to distinguish between different types of paint. Children make their own paint with pigments and yolk.
GOAL OF TASKS	To learn that everything people use comes from nature/natural world. To understand, what materials we can use to make paints and different colours. To learn how to practically make paint on our own.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Experiential learning, resource-based learning, observing, creative-problem solving.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Practical work, discussion.

EXPECTED RESULTS	Children understand what paint is and how to make one.
ASSESSMENT	Museum educators and children talk about the visit.
EVALUATION	Lesson is very effective, children are fascinated and remember the facts learned long afterwards.

Source: National Gallery of Slovenia

SUBJECT	Neuroscience, medicine, art
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Art and neuro diseases: how dementia changes the perception of the outside world and consequently works of art?
LEARNING OBJECTIVES	Encouraging creativity, giving enough space for impaired visitors to express themselves and give them a chance of full experience of the works of art.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Direct use and analysis, plastic visual forms.
SPECIAL REQUIREMENTS	Cooperation with art educators, caregivers and therapists, properly adapted workspace, specific pedagogical approaches.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Art and dementia: guided tours and workshops for people with dementia and people with reduced cognitive ability.
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	- Creative activities are proven to have a beneficial effect on patients, since they activate different areas of the brain than language or speech. - Artistic creativity can calm and alleviate the accumulated negative emotions and help with an easier experience and expression of emotions, thus contributing to a reduction of anxiety and a surge of satisfaction and self-confidence. - Tailor-made activities, also available in the comfort of one's home, stimulate imagination and intuitive perception and contribute to memory training and orientation skills.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Specially adapted guided tours of the permanent collection with tactile accessories and creative

	workshops for people with dementia and people with reduced cognitive ability.
TASKS	Guided tours: discussion about the objects, people, places depicted; recognizing sounds, scents, textures, connected to depicted scenes. Workshops: painting, sculpting, drawing, colouring etc.
GOAL OF TASKS	- To encourage creativity, - to give enough space for people with dementia and with reduced cognitive ability to express themselves, - to enable positive effects of creativity on their well-being, - to give those visitors a chance of full experience of the works of art.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Setting small groups, inquiry-based learning, experiential learning, creativity.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion, creativity.
EXPECTED RESULTS	Better physical well-being, reduction of anxiety and a surge of satisfaction and self-confidence, self-expression.
ASSESSMENT	Museum educator and attendants talk about the events and give report about the visible effects after coming back to the elderly homes.
EVALUATION	Results are based on different factors: - participants' cooperation and integration during the visit, - participant's well being during and after the visit,

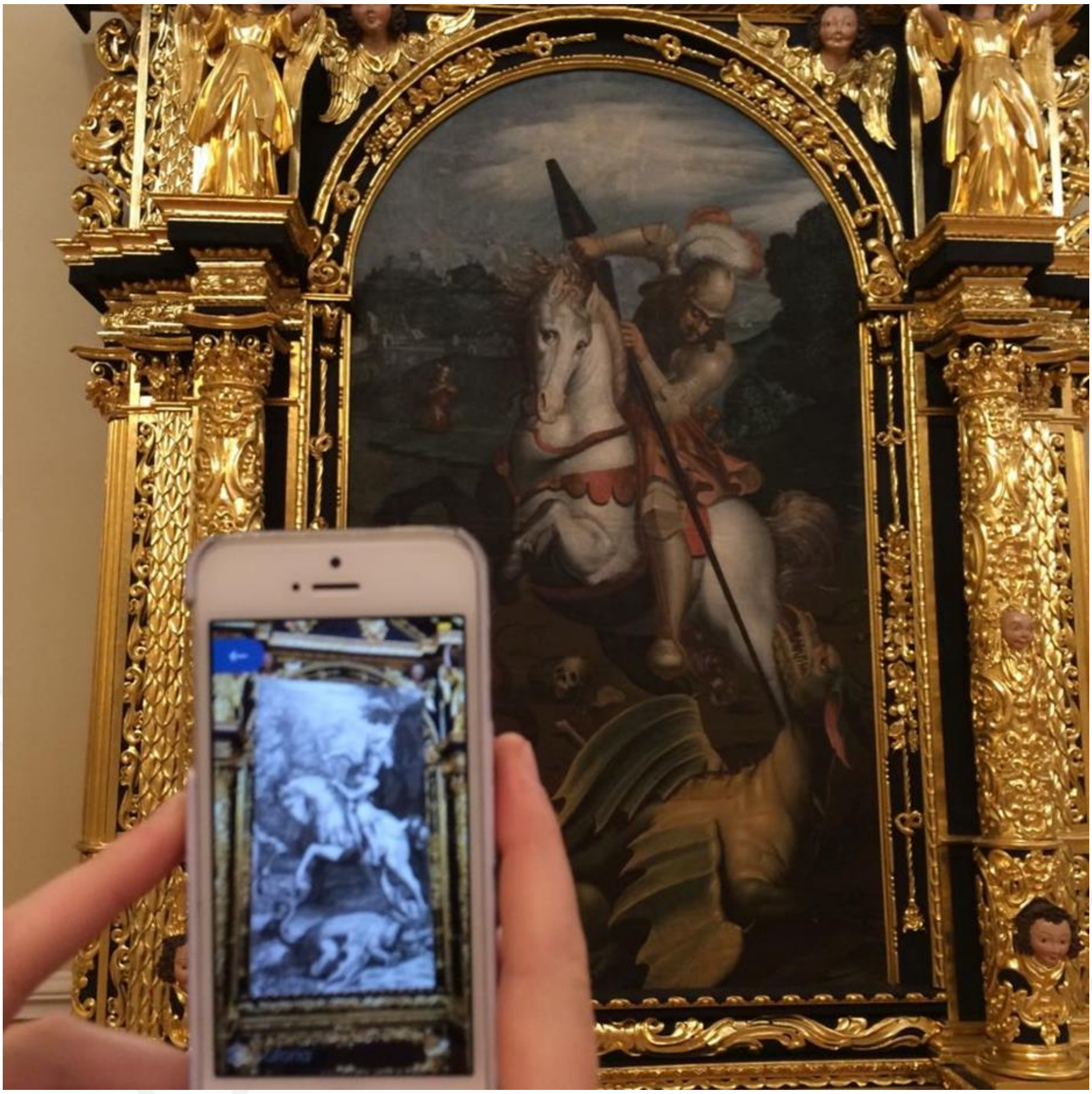
	- attendances' satisfaction with the mentor's attitude towards participants and the tasks given.

Source: National Gallery of Slovenia

SUBJECT	Art, physics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Restoration-conservational procedures and proper care of works of art at museums or at home.
LEARNING OBJECTIVES	Pupils learn: - about different types of illuminance with specific wavelengths, providing information not discernible in visible light (UVF methods (ultraviolet fluorescence), IRF (infrared photography) and IRR (infrared reflectography)), - what is retouching, - what can and did happen to some of the works of art in our permanent collection, - what are modern standards in the field of conservation and restoration, - about proper care of works of art at the museums and at home.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Direct and abstract, using IT: works of art are being explained by photos and special effects as for e. g. augmented reality (you can see the difference between the artwork as seen in the visible light or as seen under UV/IR light, where lower layers of the painting are visible etc.).
SPECIAL REQUIREMENTS	IT equipment: smart phone.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Behind the image/scenes. *Interactive mobile app quiz.*
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	Issue: - Can damage, inflicted upon the works of art, teach us how to take care of the artworks in the future? - Do we always see everything that had been painted or is there something hidden from our eyes?

	- How can we investigate, if there is something painted beneath the top layers of the paint? - Can we learn something from the research; for e.g. about the artist, about his methods of work, about the way of how the works of art were made in the past etc.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	App is free of charge and can be downloaded from mobile app stores. Available only in Slovenian. The interactive game consists of several chapters, which take the user through the permanent collection and show him/her specific injuries, pentimenti and other damage or corrections made to works of art. Some of the stations are enriched with AR and show you the paintings under different types of illumination. In the end, visitors get some professional directions on how to take care of the artworks at home (the right climate conditions, light intensity, no-touch and non-invasive approach).
TASKS	- Answer questions with several options, - puzzles, - visual quiz, - quick fingers; slide from left to right to give a correct answer, - spot the differences.
GOAL OF TASKS	To showcase how: - art and science are connected, intertwined, - physics and chemistry are necessary to completely understand the works of art, - natural sciences are inevitably connected to preservation of the artworks,

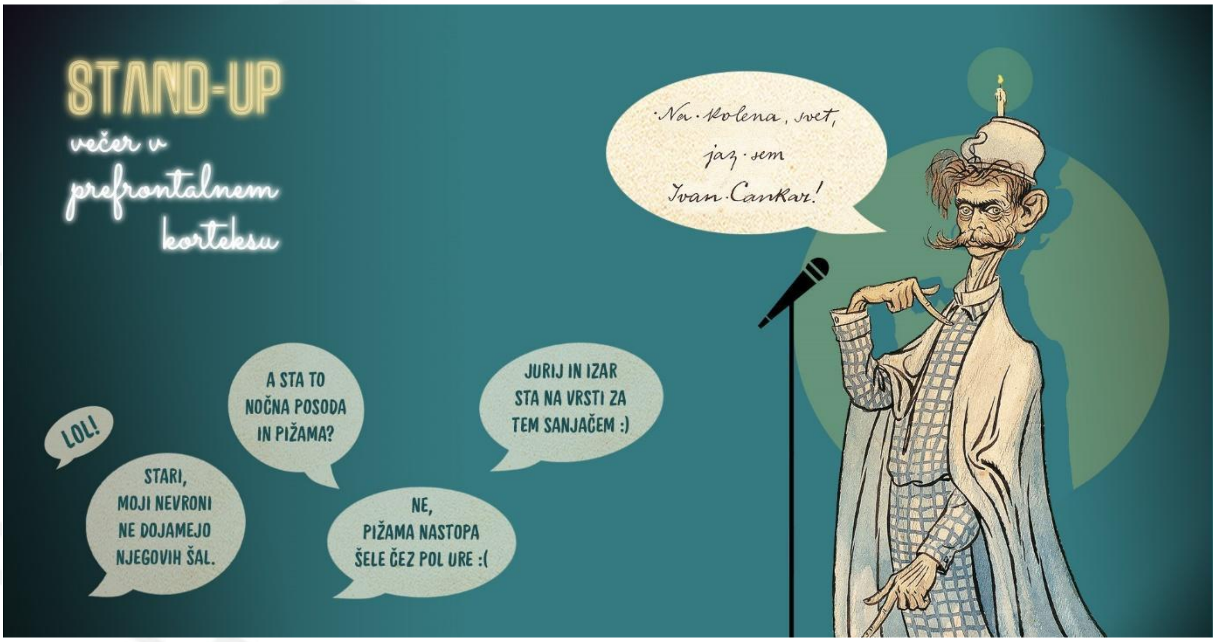
	- use of physics and chemistry help us understand the artworks, painters and methods of work in different periods of time.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Creative-problem solving, resource-based learning.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Independent research, using interactive technology.
EXPECTED RESULTS	The users understand the practical applications of scientific methods.
ASSESSMENT	Number of downloaded quizzes.
EVALUATION	Number of downloaded quizzes, responses of quiz participants.



Source: National Gallery of Slovenia

SUBJECT	Neuroscience, medicine, physics, art
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	How neuroscience and art are connected and intertwined.
LEARNING OBJECTIVES	To learn, how our mind and brain perceive the works of art and how this affects us.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Direct, metaphor, analysis, abstraction.
SPECIAL REQUIREMENTS	Cooperation with neuro scientists, neurologists, physicists, students of medicine.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Lectures about the different topics that connect art and neuroscience.
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	- The importance of art in the child development, - creativity and mental distress, - beauty ideals; how do we see and determine beauty, - imagination; is it tangible and how it affects our mind, - the difference between looking and seeing, - experiencing art and the feeling of awe; at what level is the experience physical, - our perception of works of art is connected to chemical processes in our bodies, not only our state of mind and previous knowledge about the topic discussed.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Online and on-site lectures and other types of events: discussions, round tables, research surveys …

TASKS	Listening to lectures, participation in debates and surveys.
GOAL OF TASKS	To learn how art, natural science and medicine are connected, intertwined. Give teachers insight into biological responses to art. Give teachers insight into practical applications of art (art as mood-elevator, its soothing aspects)
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Exchange of knowledge, views and experiences through lectures and discussions.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Lecture, discussion.
EXPECTED RESULTS	Understanding the practical applications of scientific methods. Recognizing that chemical processes can overwhelm us and that we cannot always have influence on our art experience. Practical examples of how art can be used in connection with neuroscience.
ASSESSMENT	Museum educator and neuro-specialists talk about the events, audience response.
EVALUATION	Lectures are very well accepted and always trigger a lively debate and exchange of opinions.



Source: National Gallery of Slovenia

4 HEUREKA

1. Videos as online learning materials

In the early stages of the OTA project, Heureka implemented short video-based lessons. Videos are to be used at the beginning of an online lesson, allowing the video to evoke and give perspective on the science topic. Video-based assignments with their school curriculum contexts constitute the actual learning experience, as they are based on the learner's personal experience and information retrieval and processing. To make the learning experience as strong as possible, complementary assignments help to widen the topic and strengthen the learning impact.

The 5-minute videos and their learning materials have been made primarily for 11-14 year old pupils and their teachers, but some of the assignments are also suitable for primary school children, and some also offer materials for high schools and hobby groups or when studying with parents at home.

The starting point for the videos were the art works from the National Gallery of Finland's collections. They contain the most significant works of Finnish art. The filming schedule was already in the autumn 2021 due to the upcoming renovation of the Gallery Museum.

Six works of classical art were selected for the videos and cutting-edge researchers were invited to share their inspiration on those art works. They told about their research work in mathematics, chemistry and physics. In addition to the information content, they were acting as role models, as the researchers were chosen for their enthusiastic presentation. Some of the chosen researchers are quite young and they told about their own research careers.

As the videos are also used elsewhere than in Finland, in the beginning of each video there is a briefing on the meaning of the work of art.

Heureka's long experience in making teaching materials for Finnish teachers helped a lot when making the videos. Interviews have shown that teachers value easily structured learning content. They appreciate rather solemn ways of telling the facts. This was kept in mind:

researchers are talking as concretely as possible. However, for all researchers, this does not work as well: for example, the topology is pretty challenging to explain in a few minutes.

This report only shows part of the videos and some of the activities connected to them. The dissemination of all the videos will be done in late spring 2022 at Heureka teachers' event. There will be a possibility to watch the videos, introduce the learning materials, and test some of them hands-on. The whole material will be marketed at Heureka Newsletter for Schools (7700 receivers), at Heureka Facebook for teachers (600 followers), and it will be presented at Heureka Learning Materials website. Combining science and visual arts in this way is so novel idea that the National Gallery of Finland intends to include the video in its own distribution.

LIST OF ALL HEUREKA'S OTA - VIDEOS (each appr. 5 min.)

Ole Kandelin: Nuorallatanssija / The Rope Dancer

Matematiikka / Mathematics

FIN https://vimeo.com/683225011/1f4bef87a3

ENG https://vimeo.com/683222067/21ba4dd028

Werner Holmberg: Kyröskoski / The Kyrö Rapids

Fysiikka / Physics

FIN https://vimeo.com/683221638/2831a6a889

ENG https://vimeo.com/683219982/e8a9f2e147

Helene Schjerfbeck: Omakuva 1915 / Self Portrait 1915

Matematiikka / Mathematics

FIN https://vimeo.com/693509490/d9a4d94bb0

ENG https://vimeo.com/693504226/c4c746560e

Hugo Simberg: Hartaus / Devotion

Fysiikka / Physics

FIN https://vimeo.com/693502439/ab86879fe5

ENG https://vimeo.com/693501179/551082c5ca

Ferdinand von Wright: Taistelevat metsot / Fighting Capercaillie

Kemia / Chemistry

FIN https://vimeo.com/632855336/4f029a3067

ENG https://vimeo.com/632855167/a15ecbbe2f

Akseli Gallen-Kallela: Purren valitus / The Lamenting Boat

Kemia / Chemistry

FIN https://vimeo.com/632856127/dc32233ed0

ENG https://vimeo.com/632855591/de991f9732

2. Enriching the learning material videos with curriculum-based exercises

The teachers emphasise that the learning materials are most usable if there is a strong connection to the school curriculum. That information is clear when they are contacted in teachers' events, continuing education events, or with emails, meetings, newsletter feedback etc.

The exercises serve as the content of all three learning phases according to the teacher's preference. They can

1) lead to a discussion of the issue (pre)

2) be the main content of the lesson (present) or

3) guide the dealing of the topic afterwards with more depth and review (post)

This was kept in mind when Heureka implemented video-based lessons in the early stages of the OTA project. The topics were chosen in grounds of Heureka expertise and contacts with teachers, and in grounds of the OTA survey for teachers, which showed the topics most needed.

Teacher members of the OTA Focus Group emphasized that the most needed pandemic online learning materials are the self-directed ones for those pupils who are faster than others or wish to concentrate on the subject. If you can see if the exercise is less or more demanding, using it is easy.

Teachers also stressed that even a good material will not be used if its connection to the curriculum is not completely clear. Therefore, Heureka will introduce a well-established presentation format, in which there is a summary presenting the connections of each task set to the learning content of school lessons. There is also a note of how demanding the exercise is. This will give the teachers an easy way to glimpse the summary to see which content is suitable to her/him.

This is important information for the creators of the learning materials, because although teachers in Finland have much more power to design the content of their own lessons than teachers in many other European countries, they still rely on ready-made frames and look for the most complete materials possible.

2.1. Enriching exercises 1 / 5

Which part of the face?

SUBJECT	Mathematics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Geometry Circle Topology
LEARNING OBJECTIVES	Understand the basic concepts of topology in the field of mathematics and that a work of fine art is the sum of its parts.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Self-portrait 1915 of Finnish artist Helene Schjerfbeck. https://www.kansallisgalleria.fi/fi/object/399658
SPECIAL REQUIREMENTS	Network connection and computer, printer, scissors.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Which part of the face?

ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	How much do you have to see to recognize a face?
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Topology is a component of mathematics that studies spatial forms such as continuity and the properties of objects that do not change when, for example, the object is twisted or stretched without tearing or glueing. The term is also used in other fields, such as biology and music.
TASKS	Watch a five-minute OTA video in which topology expert Kirsi Peltonen and art expert Anu Utriainen share their thoughts of the self-portrait of Finnish artist Helene Schjerfbeck from 1915. https://vimeo.com/693504226/c4c746560e Print a self-portrait or facial image from the web and reveal only a small part of it. You can also cut a piece of the print and guess with the others which part of the face it belongs to. Is it possible to conclude to which part of face it belongs into? The smaller the piece, the harder it is to guess. Find a printable face either on the website of the National Gallery of your home country or on the website of the Louvre Museum in Paris. https://collections.louvre.fr/en/ark:/53355/cl010062370
GOAL OF TASKS	Understand the basic concepts of topology in the field of mathematics and that a work of fine art is the sum of its parts.

TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	- Teamwork, - experiential learning, - resource based; online learning, - problem solving skills, - encouraging the creativity of the pupils.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion.
EXPECTED RESULTS	Understanding of the basic concepts of topology in the field of mathematics and that a work of fine art is the sum of its parts.
ASSESSMENT	
EVALUATION	Description of topology in your own words.

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2.2. Enriching exercises 2/5

Möbius strip

SUBJECT	Mathematics, art class
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Geometry Circle Topology

LEARNING OBJECTIVES	Understand the basic concepts of topology in the field of mathematics and practice its most famous phenomenon, the Möbius strip.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Self-portraits, especially Self-portrait 1915 of Finnish artist Helene Schjerfbeck https://www.kansallisgalleria.fi/fi/object/399658
SPECIAL REQUIREMENTS	Paper, scissors, tape, pencil.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Möbius strip
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	Möbius realized in the 19th century that it is possible to create a surface with only one side and one edge. This has been utilized in industry, for example. Conveyor belts are often designed in the shape of a Möbius strip so that their surface does not wear only on one side. Test the phenomena hands-on.
INVESTIGATIONAL STAGE	

DESCRIPTION OF THE ACTIVITY	Instructions 1: Watch a five-minute video in which topology expert Kirsi Peltonen and art expert Anu Utriainen share their thoughts of the self-portrait of Finnish artist Helene Schjerfbeck from 1915. https://vimeo.com/693504226/c4c746560e The video will lead to a discussion of the issue. Make a Möbius strip: 1. Take a strip of plain paper 2. Turn the other end over and tape the ends together. 3. Draw a line along the ribbon so that the lines line up. 4. Cut along the line. 5. You can repeat the experiment, but now cut the tape into three parts, on either side of the centerline you drew.
TASKS	Making a Möbius strip model
GOAL OF TASKS	Understand the basic concepts of topology in the field of mathematics and that a work of fine art is the sum of its parts.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	- Creative problem solving, - experiential learning, - problem solving skills, - linked to pupils' everyday life and societal issues.
CONSOLIDATION STAGE	

APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion, exhibition/sharing the results online.
EXPECTED RESULTS	Understanding of the basic concepts of topology in the field of mathematics and that a work of fine art is the sum of its parts. Raising problem solving skills with a connection to everyday life. Experimenting exercise.
ASSESSMENT	Can be done autonomously (suggested for pupils who have done their basic exercises faster than others).
EVALUATION	Hands-on exercise with physical results which can be shown on screen or organized as an exhibition at the classroom. Participants' cooperation and integration during the exercise tasks.

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2.3. Enriching exercises 3/5

Coin toss and learn probability

SUBJECT	Mathematics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	- Calculations, - solving real life problems, - probability.
LEARNING OBJECTIVES	Understand and test the basic concept of probability.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Games and playing in visual arts. Example: *Rope Dancer* by Ole Kandelin (1944) https://www.kansallisgalleria.fi/fi/object/471618
SPECIAL REQUIREMENTS	Coin, paper, pencil.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Coin toss and learn probability

ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	In the painting, the character is a harlequin from the Commedia dell'arte, an Italian improvisational theater popular in the Middle Ages. Theatrical performances were based on ready-made characters whose looks and relationships with each other were predetermined. The intriguing harlequin character constantly plays games based on cheating and cheating. A game that often feels like cheating is based on knowledge: by calculating and estimating probabilities, winning is possible. Test hands-on the phenomena of probability on games.
INVESTIGATIONAL STAGE	

DESCRIPTION OF THE ACTIVITY	Toss a coin and take notes on the results. Toss the coin ten times and write down how many tails and heads (the sides of the coin) you get. Make a throw-in series and record the results two more times ten sets. For example, what is the probability that tossing a coin will give you a head three times in a row? 1/8, as the possible sequences of throw results are (0, 0, 0), (0, 0, 1), (0, 1, 1), (0, 1, 0), (1, 0, 1), (1, 0, 0), (1, 1, 0) and (1, 1, 1). And what is the probability that if you already have two heads, the next roll will also be a head? 1/2, because the coin doesn't know what you've thrown before. Each new throw is unique. Why does not the result you throw yourself seldom match the probability? Try to see if the result starts to approach 50/50 if you toss a coin a hundred times. Think about how much practice would be needed to make the coin spin as you wish and consider the role of chance in coin tossing.
TASKS	Toss coin. Take notes to prove the laws of probability.
GOAL OF TASKS	Understand and test the basic concept of probability.

TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Creative problem solving, experiential learning, inquiry-based learning.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion, sharing the results online. Can be executed as role-playing.
EXPECTED RESULTS	Understanding of the basic concepts of probability and how probable it is to win in gambling.
ASSESSMENT	Can be done as a group work or autonomously (suggested for pupils who have done their basic exercises faster than others).
EVALUATION	Hands-on exercise. Participants' cooperation and integration during the exercise tasks. Description of probability in your own words.

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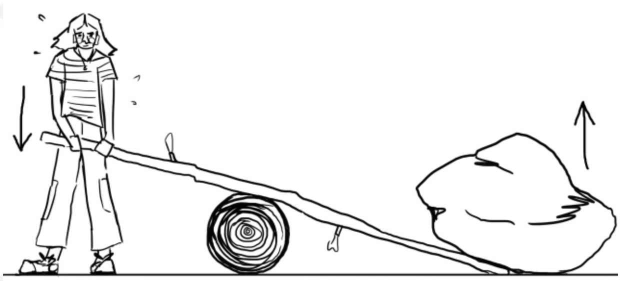
2.4. Enriching exercises 4/5

The lever brings power



SUBJECT	Physics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Forces Assembling forces Lever, power
LEARNING OBJECTIVES	Understand and test the basic concept of force and levels.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Visual arts. Example: Painting *Kyrö Rapids* by Werner Holmberg (1854) https://www.kansallisgalleria.fi/fi/object/398298
SPECIAL REQUIREMENTS	Long stick, heavy object, a sturdy podium.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	The lever brings power

ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	The painting *Kyrö Rapids* shows a building, a sawmill, where the power of moving water was transferred to equipment for sawing logs into boards. Leverage was used in the transmission, among other things. Leverage is effective because when the fulcrum of the lever arm is near one end thereof, a small force can produce a large amount of movement. Lifting the load is lighter the closer the load is to the fulcrum and the longer the lever arm is. The long arm of the lever thus facilitates the work, for example, when crocheting a heavy object to another location. A support point placed close to the object to be moved facilitates the work. Try this in practice.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Try moving a heavy object first with a short, then a long lever. Test the effect of a support point placed near or far from an object (such as a stone or a piece of plank under a lever). If you are levering a very heavy object, take care of your safety. The lever arm should be made of durable material, as the force on the lever arm can be so great that the lever arm pops out uncontrollably or breaks violently.
TASKS	Test the efficiency of the lever arm in practice with tools found at home.
GOAL OF TASKS	Understand and test the basic concept of forces and levers.

TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	**-** Inquiry based learning, - experiential learning, - problem solving skills, - linked to pupils' everyday life and societal issues, - relevance of science in the society, - possible to use online or as a classroom activity, - small groups, teamwork possibilities, - encouraging the creativity of the pupils.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion, sharing the results online.
EXPECTED RESULTS	Understanding of the basic concepts of forces and usage of levers.
ASSESSMENT	Can be done as a group work or autonomously.
EVALUATION	Hands-on exercise results, discussion of the results. Participants' cooperation and integration during the exercise tasks.

Heureka

2.5. Enriching exercises 5/5

The core of the rain

SUBJECT	Physics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Meteorology –Atmospheric phenomena and weather Climate research
LEARNING OBJECTIVES	Understand and test the basic concept of small particles in climate research, and of the global scale of it.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Visual arts. Example: Painting *Kyrö Rapids* by Werner Holmberg (1854). https://www.kansallisgalleria.fi/fi/object/398298
SPECIAL REQUIREMENTS	Network connection. (A3 sheet for making a poster, colored pencils, or a printer).
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	The core of the rain

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

ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	In the video, postdoctoral researcher Otso Peräkylä talks about the circulation of water: evaporation, condensing first into clouds and then into rainwater. Recent climate research has revealed that tiny particles in the air are crucial in rain drops formation. What does that mean to climate change?
INVESTIGATIONAL STAGE	

DESCRIPTION OF THE ACTIVITY	Stage 1: Watch a five-minute video in which physics researcher Otso Peräkylä and art expert Anne-Maria Pennonen share their thoughts of the work Kyrö Rapids (1854) by Finnish artist Werner Holmberg. https://vimeo.com/683219982/e8a9f2e147 Stage 2: Read the text below and watch the animation of the volcanic eruption cloud spreading to understand the main content of the lesson https://www.youtube.com/watch?v=K-4TB47N3_Y Based on what you see, prepare a poster, elevator pitch, or an opinion paper on why air pollution is not just a local problem, but a global challenge. Finnish researcher Markku Kulmala is a famous climate change researcher who has studied the effect of *small particles* on rainfall and the climate. *Small particles* are airborne particles smaller than 2.5 micrometers in size. They are naturally generated, for example, when the wind raises sand or tiny salt particles evaporate from the sea, and they act as condensation centers for the raindrops. The droplets begin to accumulate around them. Man-made air pollution has significantly increased the number of *small particles*. Polluted air has up to a thousand times more condensation cores than clean ocean air. The residence time of small particles in the atmosphere varies from a few days to a few months, during which time the particles do not have time to distribute evenly in the atmosphere. Still, air currents can carry *small particles* for thousands of miles. In the spring of 2020, the volcano Eyjafjallajökull erupted in Iceland. The ash rose to an altitude of eight kilometers, from which it was transported by air currents, especially in Europe. There was so much ash in the atmosphere that it threatened to clog the engines of the planes. As a result, air travel was canceled in Europe, and passengers around the world had to come up with other ways to return home. One volcanic

	eruption could cause considerable chaos in the modern world. Watch a short animation about the spread of ash from the Eyjafjallajökull volcano in the atmosphere https://www.youtube.com/watch?v=K-4TB47N3_Y Investigate the animation and use it as an example of why air pollution is not just a local problem but a global challenge. The reasoning can take the form of a visual poster, a 5-minute "elevator pitch," or a brief opinion paper.

TASKS	Watch short documentary videos to form your own opinion of air pollution as a global challenge.
GOAL OF TASKS	Understand and test the basic concept of meteorology and climate research.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	- Inquiry based learning, - experiential learning; learning through experiences, - problem solving skills, - linked to pupils' everyday life and societal issues, - relevance of science in the society, - possible to use online or as a classroom activity, - small groups, teamwork possibilities, - encouraging the creativity of the pupils.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion, sharing the results online. Poster exhibition or a series of short talks - voting for the best talk.
EXPECTED RESULTS	Understanding of the basic concepts of climate research.
ASSESSMENT	Can be done as a group work. Suites well the pupils in need of an autonomous demanding task.
EVALUATION	Presentations (posters, short talks etc.), discussion of the results. Participants' cooperation and integration during the exercise tasks.

Heureka

5 INNOVADE

1

SUBJECT	Physics
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Forces – Newton's Laws of Motion
LEARNING OBJECTIVES	-To learn about forces, -to apply Newton's Laws of Motion, -to learn about inertia and centrifugal force, -to make their own paint spinner craft, using kitchen tools.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Painting.
SPECIAL REQUIREMENTS	Salad spinner, paint (preferably tempera), paper plates.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Newton's Laws of Motion via an art craft!

ISSUE/PROBLEM (society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)	How do forces work in everyday life?
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	This activity is about applying Newton's Laws of Motion to a salad spinner art. Students learn about forces in a fun, aesthetical way!
TASKS	STEP 1: Students in groups of 2/or individually gather the material they will use. STEP 2: Students place the salad spinner on a flat surface and put a paper plate on the bottom of it. Alternatively, they can cut a piece of paper to fit in the bottom. STEP 3: They add drips and drops of paint all around the surface of the paper plate. STEP 4: When they are satisfied with the amount of paint, they close up the salad spinner tightly and get it spinning! STEP 5: Students are then asked to explain the outcome and the reasons why this happens. <u>Extra step for advanced students:</u> The teacher can ask: What happens if they thin the paint first with a bit of water? Does changing the viscosity or thickness of the paint have a different effect?

GOAL OF TASKS	- To apply Newton's Laws of Motion - To learn that an object in motion stays in motion unless a force is acted upon it. The paint spinner is a great example of inertia. - To learn about centrifugal force - the tendency of an object following a curved path to fly away from the centre point. Here the colours on the paper plate are pushed outward, when the salad spinner turns, causing the colours to mix together.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Experiential learning, observing, teamwork.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Practical work, discussion.
EXPECTED RESULTS	Students understand how forces work via everyday life examples.
ASSESSMENT	Discussion on how this activity is connected to Newton's laws of motion.
EVALUATION	Students can think of other everyday examples of the effect of forces!

INNOVADE

2

SUBJECT	Maths
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Geometry - Pythagorean Theorem
LEARNING OBJECTIVES	-To learn about the Pythagorean Theorem, -to create their own snail-like spiral.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Drawing.
SPECIAL REQUIREMENTS	Sharp pencil, ruler, paper, calculator.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	The Pythagorean Theorem on a snail-like spiral
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	How can we create a drawing using mathematical equations?
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Inspiration for the activity: https://www.youtube.com/watch?v=vrs2uGV_XRs The activity is about the Pythagorean Theorem and how to apply it to construct a snail-like spiral with a number of interesting properties. This spiral is called a square root spiral or Theodorus spiral.

TASKS	Students are first taught the Pythagorean theorem and apply it to some mathematical exercises. If you're just introducing the basic concepts, the spiral is a useful activity on Pythagoras' theorem. They are introduced to the activity: Step 1: Students individually gather the material they will use. Step 2: To construct a spiral, they make a right angle with sides A and B of equal length, which becomes the "1" value. Next, they make another right triangle using side C of their first triangle – the hypotenuse – as side A of the new triangle. They keep side B the same length at their chosen value of 1. Step 3: They repeat the same process again, using the hypotenuse of the second triangle as the first side of the new triangle. It takes 16 triangles to come all the way around to the point where the spiral would begin to overlap their starting point, which is where ancient mathematician Theodorus stopped. Step 4: Students are asked what they observe. Step 5: Students are asked to explain the outcome.
GOAL OF TASKS	- To learn about the Pythagorean theorem, - to create their own snail-like spiral, - the spiral's resemblance to a snail shell provides an opportunity to discuss the ways mathematical relationships show up in the natural world, and helps create colourful decorative schemes.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Experiential learning, resource-based learning, observing.
CONSOLIDATION STAGE	

APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Practical work, discussion.
EXPECTED RESULTS	Students understand how to apply the Pythagorean theorem on a drawing.
ASSESSMENT	Students end up with a spiral shape. Teacher can choose a triangle from the spiral for each student and ask them to explain the mathematical equitation.
EVALUATION	Students are asked to explain the spiral in mathematical terms – to write down the mathematical explanation of their spiral – in this way the teacher evaluates if students understand the theorem.

INNOVADE

3

SUBJECT	Chemistry
TOPIC FROM CURRICULUM GENERAL TOPIC: SUBTOPIC	Elements of the periodic table
LEARNING OBJECTIVES	-To learn about the properties of different elements of the periodic table, -to create their own collage.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Collage - cutting and sticking.

SPECIAL REQUIREMENTS	Worksheets with questions for different elements, internet/ computer, printer, piece of cardboard, glue, scissors.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	The Periodic Table of Elements Collage
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	The chemical elements in everyday life.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	The activity is about exploring the different elements of the periodical table by creating a collage with images.
TASKS	Step 1: Students in groups of 3 are assigned an element. Step 2: Students are given worksheets with questions about that element and specific Internet sites to get the information. Step 3: Students gather their images based on their research. Step 4: In a given format, the students create a collage of images, including the name of the element, the symbol, atomic mass, and atomic number, everyday uses of the element. Step 5: The teacher can collect everything and make a large periodic table on a wall. Step 6: Each group can present their work; students also describe how each chosen image is connected to the element.

GOAL OF TASKS	-To learn more about the different elements of the periodical table, -to learn the properties and everyday uses of these elements.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Experiential learning, resource-based learning, teamwork.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Practical work, discussion.
EXPECTED RESULTS	Students understand the properties and uses of different chemical elements.
ASSESSMENT	Groups exchange their cardboards- collages and see if they can add any other image on it.
EVALUATION	Students are asked to give examples of different uses of the elements in everyday life.

INNOVADE

4

SUBJECT	Analogies
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Maths Geometry
LEARNING OBJECTIVES	-Explain the use of analogies for aesthetic and practical reasons. -Utilize analogies to construct own art works.

ART EXPRESSIOSIONS/VISUAL FORMS USED	Pyramid model.
SPECIAL REQUIREMENTS	-Pyramid model, bar, -wooden stick.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Learning about analogies.
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	What are the analogies? How do they affect our life? Criteria of beauty in art and social life.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Pupils will firstly replicate the famous measurement that Thales used in order to find the exact height of a pyramid, using nothing but an ordinary wooden stick. As soon as they have recognized the effectiveness of the analogy, they are introduced in their use in everyday life.
TASKS	1. Pupils read the testimony of the text about how the measurement of pyramid height is attributed to Thales. With the help of the pyramid model, as well as a bar, students try to understand in an experiential way how Thales was able to measure the height of the pyramid. 2. Pupils are asked to measure the analogy of torso and legs of ancient statue and today's models. Then they are asked to comment on their findings.
GOAL OF TASKS	- Pupils are introduced in the concept of similarity of triangles and shapes. - Pupils connect the similarity with the parallel. - Understand the meaning of the similarity ratio. - Pupils are introduced to the general historical and social framework, which through democracy and its implied legal reason, created the conditions for the emergence of theory and proof.

TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Inquiry-based learning.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion on how the analogies are perceived in everyday life. Clear distinction between body analogies for aesthetic reasons and phenomenon of bad mimetism or even exclusion due to lack of 'perfect' analogies. Question to be asked: is beauty just an outcome of analogies?
EXPECTED RESULTS	Pupils are expected to refer to the same analogical principles to describe other incidents of their everyday life (symmetry of famous buildings, analogies in well-known logos, mathematical proofs).
ASSESSMENT	Each student should find the analogies in some (object, person, building) that he/she considers as beautiful and make remarks on his/her findings.
EVALUATION	

INNOVADE

5

SUBJECT	Artistic study of clouds
TOPIC FROM CURRICULUM **GENERAL TOPIC:** **SUBTOPIC**	Physics
LEARNING OBJECTIVES	-Identify clouds outside the classroom using an identification matrix, -recognize how artists depicted clouds in art, -identify cloud types depicted in works of art, -create own art to depict cloud types.
ART EXPRESSIOSIONS/VISUAL FORMS USED	Landscape paintings mainly from the 19th Century from Europe and North America.

SPECIAL REQUIREMENTS	-Paint color samples (including blues, whites, red/pink, greens, purple, grey), -cloud matrix (e.g https://www.weather.gov/media/jetstream/clouds/cloudspotter.pdf). Different inputs of cloudy sky (or direct identification in the field). A collection of landscape paintings that include sky and cloud representations.
MOTIVATIONAL STAGE	
TITLE OF THE LESSON	Clouds and art.
ISSUE/PROBLEM **(society issue, issue that is seen relevant from pupils' perspective, issue linked to some nature phenomenon or phenomenon from pupils' everyday life)**	Pupils learn to notice and describe clouds in the atmosphere in order to identify cloud types and learn about their effect in weather conditions.
INVESTIGATIONAL STAGE	
DESCRIPTION OF THE ACTIVITY	Observe at the sky on a cloudy day. Ask students to use adjectives to describe the clouds they see. How much of the sky is covered with clouds? Are the clouds small or large? Provide each student or student pair with a cloud matrix. Practice identifying a cloud together as a group. Then challenge students to identify clouds on their own. Note: cloud identification can be challenging. Many teachers focus on recognition of just three cloud shapes (cumulus, stratus, and cirrus) in order to keep things simple, while students initially learn about cloud types. If you wish to simplify with these categories, you will need to adjust the presentation and use a simplified cloud identification guide. Tell students that, for this lesson, they will explore how artists depict clouds in paintings. They will make careful observations and hone their cloud identification skills by looking at clouds in art.

TASKS	Run through several landscape paintings. Have students use their cloud viewer or cloud identification guide to help identify the cloud types in a piece of art, record their answer, and then flip to the next slide which gives the answer. For each painting, ask students to notice what the weather looks like, the colors that the artist used to paint the clouds, and the types of brushstrokes. Prompt students to use adjectives to describe what the clouds look like.
GOAL OF TASKS	Students learn to notice and describe clouds in the atmosphere in order to identify cloud types.
TEACHING METHODS: (creative-problem solving, resource-based learning, inquiry-based learning, setting small groups, teamwork, experiential learning)	Experiential learning.
CONSOLIDATION STAGE	
APPROACH/METHOD (discussion, argumentative debate, role-playing …)	Discussion on the different clouds type and the criteria that scientist use in order to distinguish cloud's categories.
EXPECTED RESULTS	Students will understand the different cloud types and be able to extract meteorological information from paintings representing landscape.
ASSESSMENT	Recognition of different cloud types.
EVALUATION	Show to class a painting that depict a landscape and ask the students to comment on the weather conditions and other climate evidences extracted from the details of the painting (orientation, session etc).

INNOVADE