THE ENLIVENED LABORATORIES LIBRARY AND TOOLKITS

Enlivened Laboratories within STEM Education (EL-STEM)

Motivating EU students to choosing STEM studies & careers and improving their performance in courses related to STEM education.

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

This document is issued within the frame and for the purpose of the Enlivened Laboratories within STEM Education project, funded by the European Commission-Erasmus+/ Key action 2, Cooperation for Innovation and the Exchange of Good Practices/ KA201 - Strategic Partnerships for school education (Ref. #: 2017-1-CY01-KA201-026775)

Intellectual Outputs	IO3: The Enlivened Laboratories Library and Toolkits (Lead Open University of Cyprus) IO5: AR/MR Learning Objects (Lead Doukas Ekpaideftiria AE) IO6: Lesson Plans for Remote and/or Local Laboratories within STEM Courses (Lead Helsingin Yliopisto)
Contributing partners	All Partners
Status-Version:	Final
Date:	30/12/2019
Executive Summary:	The Enlivened Laboratories Library and Toolkits (IO3) are provided as Open Educational Resources (OER) for everyone to visit, learn, enjoy and contribute. The key aim is to help teachers and students augment the educational experience utilizing the EL STEM Methodologies in combination with rich educational content developed with AR/MR/VR tools. IO3 complements the pedagogical framework established by the pedagogical foundations of Intellectual Outputs IO1-Accounting for Diversity and Accountability, and IO2-Enlivened Labs Methodological Guidelines (ELMG). It includes a number of diverse Lesson Plans (LPs) and Learning Objects (LOs) in STEM subjects, a selection of AR/MR/VR reviewed tools with respective user guides and references to case studies from other toolkit users. The IO3 resources were created by the Project EL STEM Partners as well as by Teachers participating in the Training Courses offered. The contents were continuously revised and enriched as the Teacher Training was gradually being developed. Indicative Library contents are presented at the Project website (elstem.eu) and the complete contents are available mainly via Module 5 of the EL STEM Project Teacher Training, which can be accessed with self-registration at the online environment site (elstem.ouc.ac.cy).

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Open Educational Resources (OER) License

The Erasmus+ KA2 Project EL STEM (Ref. #: 2017-1-CY01-KA201-026775) outputs were developed by the following Partners:

1. Open University of Cyprus (CY)
2. European University of Cyprus (CY)
3. University of the Aegean (EL)
4. University of Tartu (EE)
5. Ingeniarius, Lda (PT)
6. Gymnasium Palouriotissas (CY)
7. Douka Ekpaideftiria AE (EL)
8. MTÜ Tartu Erahariduse Edendamise Selts (EE)
9. Viikki Teacher Training School (FIN)

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- Use the work;
- Adapt the work as needed (e.g. translate, shorten, modify for local contexts, etc.);
- Reproduce and share the original or adapted work with others (e.g. with students in the classroom, online, with peers, etc.).

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- That the creator has to be indicated whenever the work or a derivative is used or shared;
- That the work cannot be used commercially (e.g. sold by others, integrated in a commercial textbook, etc.);
- That any derivatives have to be shared under the same license or licensing terms.

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Abbreviations/Acronyms

Abbreviation/ Acronym	Description
AR	Augmented Reality
CY	Cyprus
EE	Estonia
EL	Hellas (Greece)
ELMG	Enlivened Laboratory Methodological Guidelines
EL-STEM	Enlivened Laboratories within Science, Technology, Education and Mathematics
EU	European Union
FI	Finland
ICT	Information Communication Technology
IO	Intellectual Output
IoT	Internet of Things
LO	Learning Object
LP	Lesson Plan
M#	Month of the project time plan (M1-M30)
MR	Mixed Reality
OER	Open Educational Resources
PT	Portugal
STEM	Science, Technology, Education and Mathematics
VR	Virtual Reality
WP	Work Package

EL-STEM Project Description

The Project objective is to develop a new approach which combines Augmented Reality (AR)/Mixed Reality (MR) technologies with Remote and/or Local Laboratories, for encouraging secondary school students' engagement with STEM (Science, Technology, Education and Mathematics). In particular, we are targeting students of lower and upper secondary schools and irrespective of the expected varying individual inclination to STEM subjects, and we are aiming to:

(a) attract students who currently might not be interested in STEM related studies/careers and enhance the interest of those who have already chosen this field of studies/careers,
(b) improve students' performance in courses related to STEM education.

Inspired by emerging technologies of IoT (Internet of Things) and AR (Augmented Reality), we wish to connect the physical laboratory and/or the remote laboratory to the digital world and turn it into an "Enlivened Laboratory". We aim to explore various digital solutions to "immerse" students within STEM laboratories while implementing experiments. Moreover, we aim to attract more students to STEM related studies/careers through intense hands-on experiences, where they can participate, transform and augment what they are implementing, thus applying digital competences, developing haptic skills, collaborating with peers and ultimately, becoming more engaged in STEM education. This approach will be supported at school as well as at home through the involvement of appropriate platforms offering remote access to laboratories.

Acknowledging the crucial role of teachers in any effort to bring about change and innovation, our project will make available the necessary knowledge, indicative tools, and will introduce underlying dynamics in teaching cultures that will enable STEM education to obtain the full benefits of AR/MR. This will be achieved by providing teachers with high quality professional development opportunities to acquire knowledge and skills to effectively embed AR/MR in teaching and learning. More specifically, we will create a framework for providing teachers with innovative digital tools to enrich their laboratory-based courses, in order to not only attract students' attention towards STEM education but also to achieve better performance in STEM related subjects and in general competences expected today in labour market and in life-long learning process. Project outputs will include AR/MR educational scenarios implemented through Remote and/or Local Laboratories. The technologies used for the implementation of these scenarios explore where applicable, the utilization of (a) AR/MR Remote Laboratories, (b) AR/MR Local Laboratories, (c) Mobile Technologies (e.g. smartphones and/or tablets), and (d) AR hardware technologies (e.g. AR glasses) in the teaching and learning of STEM courses.

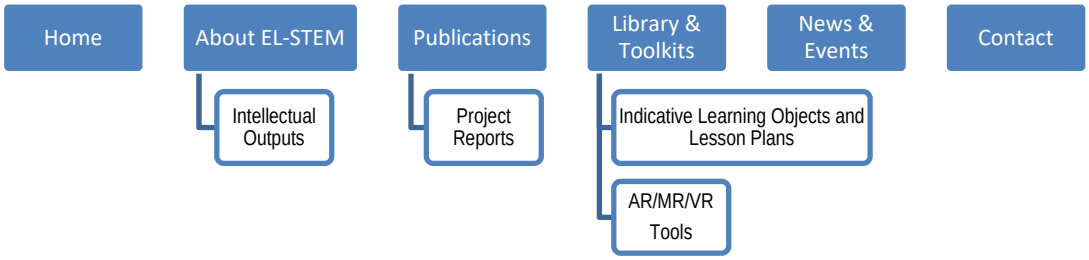
1. Introduction

The Intellectual Output 3 (IO3) Enlivened Laboratories Library and Toolkits, is provided as Open Educational Resource (OER) for teachers and students across Europe and beyond, to visit, learn, enjoy and contribute. The aim is to help teachers and students enliven the educational experience with rich AR/MR technologies, by utilizing a selection of reviewed tools and associated resources from Project EL STEM IOs, such as sample AR/MR interdisciplinary Lesson Plans and Learning Objects in STEM subjects.

The Enlivened Laboratories Library and Toolkits is fully utilized in the EL STEM online Teacher Training course (mainly Module 5), while links to indicative contents are also presented by the project website, at http://elstem.eu. The online Teacher Training is available through Project learning environment at, https://elstem.ouc.ac.cy/.

2. Introducing the Library and Toolkits via the EL-STEM website

The EL-STEM website (elstem.eu) provides a high level introduction to IO3-The Library and Toolkits. Specifically, the EL STEM Library is introduced to the visitors for a general orientation under menus *About EL-STEM→ Intellectual Outputs, Publications→Project Reports, and Library &Toolkits* as shown below.



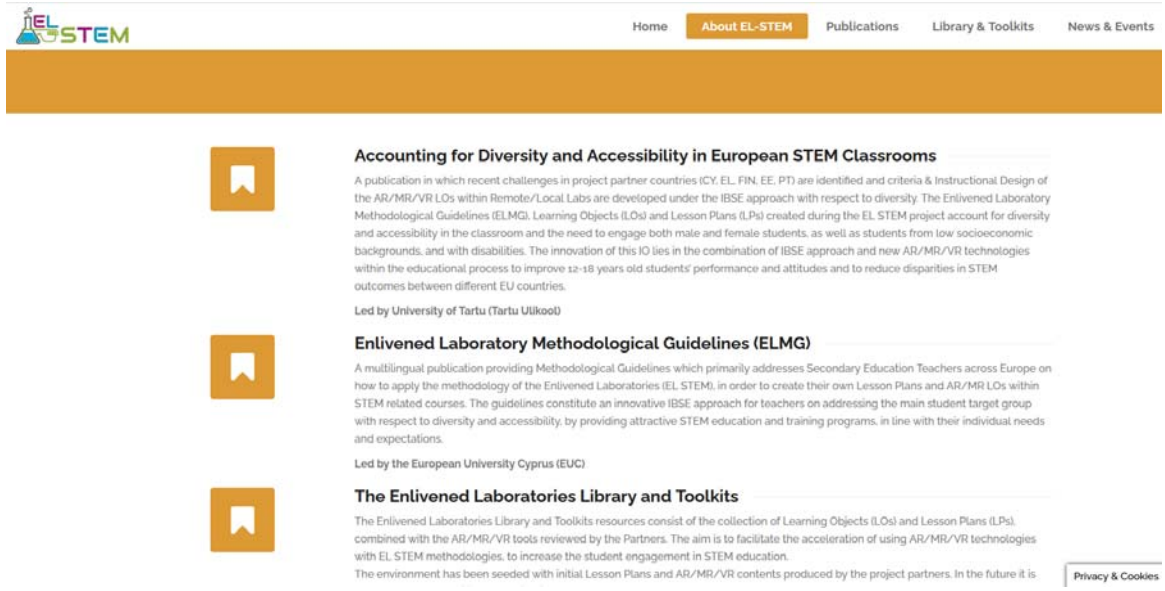


Figure 1. EL-STEM website references to IO3

3. Enlivened Laboratories Library and Toolkits Implementation

This section describes the process of the tool/applications selection as well as the implementation and the continuous development of the Library and its contents, i.e. the reviewed tool suggestions, the Learning Objects and Lesson Plans, and accompanying guides and supporting materials.

3.1. Selecting AR/MR/VR tools for review

Starting with the first EL STEM Project Meeting, the Partners discussed the main attributes and the criteria of the tools that would be evaluated, the Project Proposal budget restrictions, as well as the ways the selected tools would be incorporated into the other IOs of the Project.

It is noted that given the large reduction of the EL STEM Project Proposal budget for "Exceptional Costs" by the Erasmus+ Agency, it was evident that a major emphasis had to be on Open Source tools, which were available free. Of course, the budget reduction, which made it necessary to focus on Open Source tools, had the positive side effect of facilitating the use of the emerging AR/MR/VR technologies by Schools, teachers and students everywhere. However, the Partners realized that the available Open Source tools were lagging behind the respective commercial tools: they were more difficult to use, they had few minor or no libraries of re-usable resources, and their products were not as impressive as those from commercial tools. Beyond the financial issues, the use of open source tools also meant delays would result due to the extra time needed for the evaluation, selection and introduction to the teachers.

Despite these circumstances, the Partners agreed to utilize mainly Open Source Tools, in order to facilitate the uptake of the AR/MR/VR by Schools, while in parallel to experiment with a small number of advanced commercial tools, in order to provide insights to teachers and students regarding the potential of these technologies.

Following the initial Project meeting, experimentation started by all the Partners with various tools and the experiences were discussed on the way. A major milestone for the selection of tools was the Partner Staff Meeting and the following Staff Training, at Doukas School in Athens. During the meeting, main Partner experiences with various AR/MR/VR tools were exchanged and the main drivers for the final tool selection were agreed, as shown below.

Drivers for the Tool/Application selection

- Tool functionality and quality of outputs
- Ease of use by teachers and students (i.e. not requiring programming skills)
- Availability of resources and of online support (i.e. guides, case studies, availability of active support by the creator and/or user community)
- Degree of compatibility with multiple devices, operating systems, peripheral AR/VR equipment etc.
- Cost (i.e. if applicable, unit cost and class cost of licenses)

These criteria helped the Partners arrive at an initial list of tools, which kept expanding based on the work that followed. For example, changes resulted from feedback on the proposed tools requested from the participants of the Teachers' Training Courses in Partner countries. Further, the teachers were encouraged to provide suggestions for improving the resources and also to contribute their own work to the Library.

3.2. Implementation of the Library and Toolkits

The Open University of Cyprus (OUC) implemented the EL STEM online Learning Environment (https://elstem.ouc.ac.cy/) utilizing the Moodle LMS, and led the implementation of IO3 by guiding the creation of the initial 'seed content' for the Library. The resources of this IO were gradually developed and improved during the EL STEM Project with contributions by Partners' staff as well as by Teachers participating in the Teacher Training or Multiplier events offered in partner countries. After the initial version of IO3 structure and contents in 2018, followed a continuous improvement cycle taking into consideration suggestions from Partners and Teachers until the end of the project.

During IO3 implementation, the partner Universities were actively involved in guiding the schools and the interested teachers in linking the pedagogical framework principles of IO1 and IO2 with the practical application for in class STEM teaching and learning, by utilizing the IO3 resources. The Schools spearheaded the effort to form teams of teachers from various STEM disciplines in order to created multi- and inter-discipline Educational Scenarios and Lesson Plans. Ingeniarius played a key role for this IO by demonstrating the advanced capabilities of commercial tools utilizing Unity for AR/MR/VR prototypes and by guiding the partners for using alternate development tools and for introducing gamification design principles into the design of Lesson Plans and Educational Scenarios. Subsequently, all consortium partners conducted their own assessments of tools to decide upon the preferred solutions that could be used by teachers to create their own AR/MR Lesson Plans (LPs) and Learning Objects (LOs).

3.3. The Library Contents

The Enlivened Laboratories Library and Toolkits consists of the following:

a. guidelines and templates for creating Lesson Plans (LPs) and Learning Objects (LOs) (see Appendices A and B),
b. a selection of Tools/Applications for developing AR/MR educational content, accompanied with user guides and online references to case studies (Appendix C),
c. a selection of actual Educational Scenarios, Lesson Plans (LPs) and Learning Objects (LOs) developed and shared by partners and teachers (see Teacher Training course).

Its contents are offered as OER via the EL STEM online Teacher Training course (mainly Module 5), which is hosted at the Project learning environment (https://elstem.ouc.ac.cy/). Within the Training, the numerous references are made between the pedagogical framework guidelines of IO1 and IO2 and IO4 with the resources of IO3.

3.4. Tools/Applications for developing AR/MR/VR educational content

An increasing number of software tools (i.e. applications, development suites) is becoming available for creating AR/MR/VR educational content. Teachers are encouraged to try as many as possible and decide which are best for their needs and/or probably for their school's budget. In the context of the EL STEM Library, the Partners reviewed only a small number of tools, since it is impossible to include all the existing applications and software.

The fundamental driver for tool selection was that the tools should be easy to use by teachers (i.e. without requiring programming skills). Additional factors included the (a) cost, i.e. given the budgetary restrictions for purchasing commercial tools, both by the project as well as by the Schools, an emphasis was placed on open source solutions and (b) the existence of sample resources/case studies utilizing the tool, and (c) the existence of online support.

Appendix C of this document presents an outline of the reviewed tools by Partners and Teachers and extended references are available at the Teacher Training environment (https://elstem.ouc.ac.cy/). For each tool, the following information is provided:

- Tool/Application Name
- Links where the tool/application is available
- Relevant Videos/ Tutorials (suggested by the tool/application developers)
- Step-by-Step guides on how to use the specific tool/application to create an AR/MR/VR LO based on the ELMG (IO2)
- Related posts including good practices of Lesson Plans and Learning Objects, existing or developed by the project with the tool/application.

An example of an application for creating AR/MR Learning Objects follows.

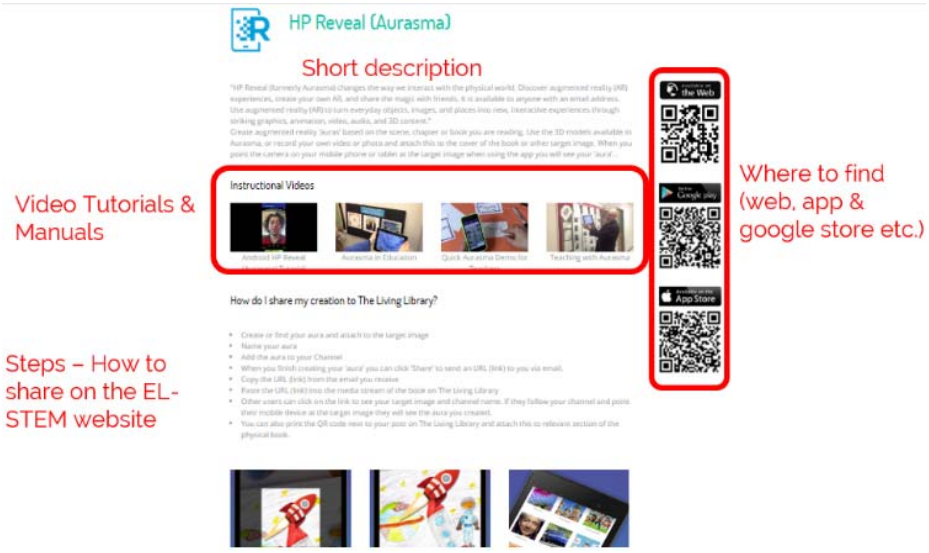


Figure 5. Example of an application for creating AR/MR Learning Objects

3.5. Lesson Plans (LPs) and Learning Objects (LOs)

A *Lesson Plan (LP)* is a Teacher's detailed description of a lesson/course that includes learning objectives, materials/aids needed, as well as the expected teaching and learning methods/activities by teachers and students for its implementation by in class. A Leson Plan template has been suggested to the teachers (see Appendix A: Lesson Plan Template **(Document)**), to be used as a basis for designing their own Lesson Plans within their STEM-related courses. This template could be modified depending each country's national guidelines and curricula. Based on the IO1 and IO2, it is suggested that the Lesson Plans created must be multi-/ cross-/inter-/ or trans-disciplinary, approaching a topic through different science fields, encouraging teachers' collaboration in order to achieve better results. Moreover, inquiry-based Science Education (IBSE) is promoted, which is closely related to STEM teaching and learning. More details about the design and development of Lesson Plans is available in the guidelines of Intellectual Outputs IO1 and IO2. All the Lesson Plans developed by the project are offered as OER via the EL STEM online Teacher Training course (mainly Module 5), which is hosted at the Project learning environment (https://elstem.ouc.ac.cy/).

An *AR/MR Learning Object* is a digital object created with any AR/MR/VR application/tool selected by the teacher, to implement educational tasks. In the context of the EL-STEM project, a specific template has been suggested for the teachers (see Appendix B: How to Design a Learning Object - OER Canvas), to be used as a basis for designing their own AR/MR Learning Objects within their STEM-related courses.

Registered users to the Teacher Training course (i.e. teachers, third parties and/or researchers in the fields of STEM and AR/MR/VR technologies in education) will be able to have their own LPs and LOs uploaded and shared with the "AR STEM Teachers" online community, so that they can be discussed and/or rated. This work will be available to view, use, augment and/or share by all users/visitors of the Enlivened Laboratories Library.

3.5.1. Metadata for Lesson Plans and Learning Objects

Basic metadata would be requested for Lesson Plans (e.g. to include a blog, an LP title and short description, relevant tags and categories), in order to enable future searches.

Indicatively, suggested tags and categories may include the following:

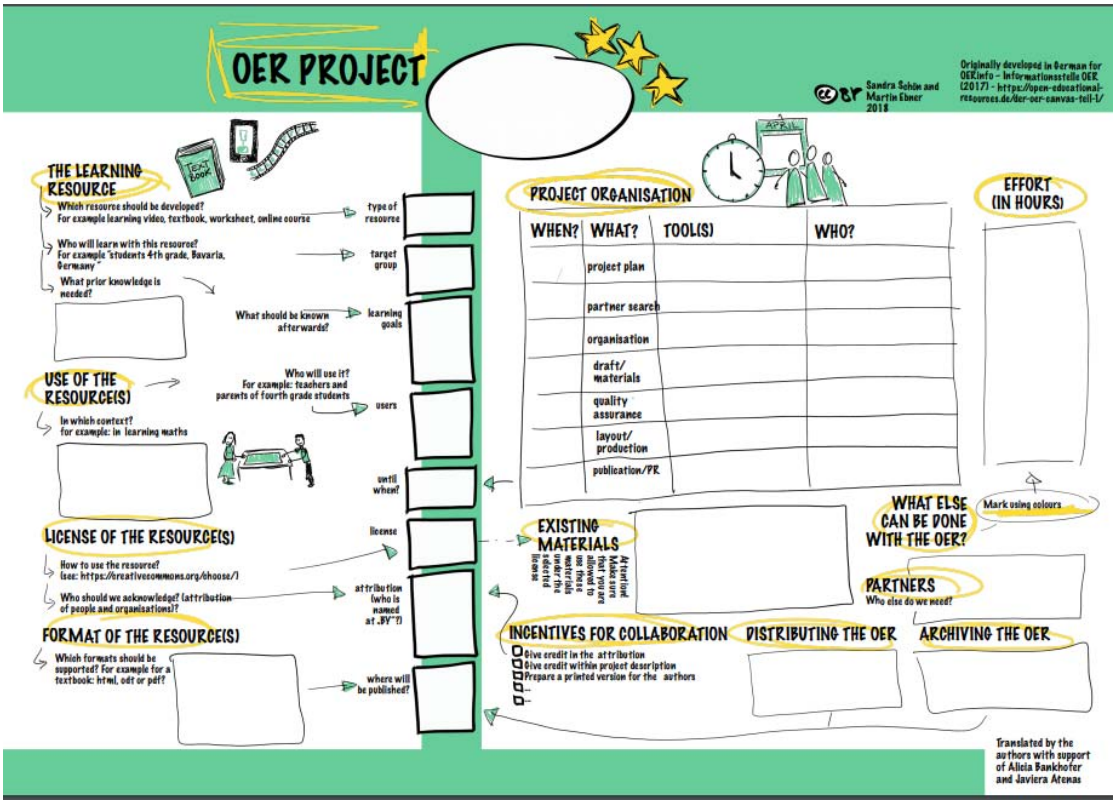
- Target Students' ge range (e.g. 14-15, 12, 15-18)
- Scientific field(s) (e.g. STEM, STEAM, Science, Mathematics, Computer Science)
- Pedagogical Approach (e.g. inquiry-based learning)
- AR tool/application used (e.g. HP Reveal, Metaverse, Unity)
- Language (e.g. English, Greek, Estonian, Finnish)
- Type (e.g. text, link, application, QR code, image, video, a collection of files exported by a specific software)

Appendix A: Lesson Plan Template (Document)

Lesson Plan Information	
STEM Disciplines:	**Curriculum alignment:**
Topic:	**Duration:**
Age Range:	**Language:**
Prior Knowledge and Skills Needed *(Prior knowledge is the knowledge the learner already has before they meet new information)*	
What prior experiences, knowledge and skills do the learners bring with them to this learning experience? e.g. ICT skills, specific knowledge on a topic previous experience on using mobile devices	
Learning Outcomes *(Learning outcomes are what students are expected to learn after completing the lesson plan)*	
Use Action Verbs for Student Learning Outcomes e.g. Knowledge (list, state, define, relate, recognize etc.) Comprehension (explain, describe, express, summarize, classify, compare, discuss, review etc.) Application (apply, perform, use, solve, role-play, demonstrate etc.) Analysis (analyze, inspect, distinguish, critique, diagnose, measure, experiment, debate etc.) Synthesis (develop, revise, compose, plan, collect, establish, prepare, design, modify etc.) Evaluation (review, justify, argue, conclude, evaluate, measure, support etc.)	
Pedagogical Approaches (Instructional Strategies ?) *(Teacher approach to helping students achieve the learning objectives and meet their needs)*	
Which pedagogical approach(es) could be applied to implement the suggested lesson plan? e.g. game-based learning, place-based learning, participatory simulations, inquiry-based learning, problem-based learning, role-playing, studio-based pedagogy, and jigsaw method	
Learning Activities *(Tasks provided for students to develop knowledge and skills of the learning objectives based on the selected instructional strategies)*	
Describe the different tasks of the inquiry-based learning phases e.g. Orientation, Conceptualization, Investigation, Conclusion and Discussion. These phases could also be enriched with components of other pedagogical approaches defined above	
Assessment and Evaluation	

(Assessment(s) before, during, and after the lesson)
If applicable. Summative, formative
Resources *(Educational material / equipment/ services/ facilities)*
What do I need in order to complete this lesson? e.g. internet connection at least 8Mbps Android smartphones iOs smartphones
Additional Information/ Comments
What else could be of additional value for the implementation of the Lesson Plan? *Mention the authors/contributors (teachers that collaborated) for this Lesson Plan.*

Appendix B: How to Design a Learning Object - OER Canvas



More information available at: https://education.okfn.org/handbooks/oer-canvas/

- OER-canvas_English
- OER-canvas_GREEK
- OER-canvas_Finnish
- OER-canvas_Portuguese

Appendix C: Reviewed AR/MR/VR Tools

Project EL STEM Reviewed AR/MR/VR Tools			
Tool Name	**Website**	**Tutorials/ Guides**	**Example Showcases**
Arloon	http://www.arloon.com	Teach with ARLOON apps (text instructions on how to use the apps in a classroom	ARLOON How to use Augmented Reality ARLOON Educational Apps ARLOON Chemistry Example
AR Tutor 2	http://aetma.ihu.gr/?page_id=5674	http://artutor.teiemt.gr/	http://artutor.teiemt.gr/
Blippar	https://www.blippar.com/blipp-builder	Blippar Tutorial Playlist	Augmented Reality for education
Entity	https://www.wakingapp.com/	ENTiTi Reality Creator AR Tutorial (video) Entiti Webinar (course - video) User Guide (document)	ENTiTi Augmented reality creator
HP Reveal (ex Aurasma)	https://studio.hpreveal.com/landing	Full Documentation including text guidelines & video tutorials Educators getting started with Aurasma-HP Reveal	AR poster using Aurasma Science Lesson with Aurasma Aurasma for education
Metaverse	https://gometa.io	Getting Started video	Metaverse intro Metaverse Showcases

Note: These tools are good examples for use during the EL STEM Project. The Project does not promote any particular tool, but instead urges everyone to keep experimenting with various tools and select those that best suit their needs.

LayAr (part of the Blippar Group)	https://www.layar.com	https://www.layar.com/support/	LayAR case studies
Microsft ThingLink	https://appsource.microsoft.com/en-us/product/web-apps/thinglink.thinglink_for_teachers_and_schools?tab=overview	https://appsource.microsoft.com/en-us/product/web-apps/thinglink.thinglink_for_teachers_and_schools?tab=Details%20%2B%20support	See Microsoft site for continuous revisions.
Merge Cube	https://mergeedu.com/	https://mergeedu.com/	https://mergeedu.com/
Scratch 3.0	https://scratch.mit.edu/	https://scratch.mit.edu/projects/editor/?tutorial=getStarted	https://scratch.mit.edu/ideas
Unity	https://unity3d.com/	How To: Augmented Reality App Tutorial for Beginners with Vuforia and Unity 3D (video) Official Tool Manual (webpage-text) Learn Unity (official courses)	Augmented Reality Educational Game
Z-Space	https://zspace.com/	https://zspace.com/edu/learn	https://zspace.com/edu/
ZapWorks	https://zap.works/education/	Full Documentation including text guidelines & video tutorials & Best Practices	STEM learning with AR (solar system expedition) Books powered by Zappar come to life in your hands Lesson Plans for using Zappar

Note: These tools are good examples for use during the EL STEM Project. The Project does not promote any particular tool, but instead urges everyone to keep experimenting with various tools and select those that best suit their needs.

Appendix D: Sample Lesson Plans

EL-STEM LESSON PLAN TEMPLATE

(this template could be used as the basis for the design of a lesson plan in the context of STEM-related disciplines applying interdisciplinary approaches and supported by Augmented Reality)

Lesson Plan Information	
STEM Disciplines: *Mathematics* **(Maths Teacher:** Pontiki Andria**)**	**Curriculum alignment:** Chapter 1: Real Numbers
Topic: Pythagorean theorem	**Duration:** 40 minutes
Age Range: 13-14 years old	**Language:** English

Prior Knowledge and Skills Needed

(Prior knowledge is the knowledge the learners already have before they come across new information)

- Identification of vertical sides and subordinate to a rectangular triangle.
- Triangle and square area.
- Dynamics and square root calculation.

Learning Objectives

(Learning objectives are the knowledge and skills students are expected to acquire after attending the course based on the lesson plan)

Knowledge-Comprehension

- Proof and formulation of the Pythagorean theorem.
- Applying the Pythagorean theorem to a rectangular triangle for calculating its sides.

Application - Analysis - Synthesis

- Students use problems from everyday life as an exploration/motivation.
- Students develop claims and critique of reasoning through the tools provided to them.

Evaluation

- Students develop the ability to use data/problem solvers to select the appropriate strategy to solve problems.
- Students develop the ability to lead to a scientifically correct conclusion by evaluating the reasonableness of their response and applying this conclusion to other activities.

Pedagogical Approaches

(Teacher's approach to help students achieve the learning objectives and meet their needs)

- ► Learning through a problem of everyday life.
- ► Learning through exploration and investigation.
- ► Collaborative learning (activities of students in groups, discussion in groups).

Learning Activities

(Tasks provided for students to develop new knowledge and skills based on the selected pedagogical approaches)

► **Activity 1 :** Exploration (as motivation) using image and video (hp reveal application), through which students discover the need to find a relationship that connects the sides of a rectangular triangle.

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► **Activity 2 :** Exploration with the proposed appendix of the school book, so that students can discover, through induction, Pythagorean theorem.

► **Activity 3 :** The formulation of Pythagorean theorem by students and its application to solve the problem of "Romeo" (a picture given to them at the beginning of the lesson).

► **Activity 4 :** Applications for the establishment of the lesson :

- Exercises 2, 3 page 50 that are applications of the Pythagorean theorem in which the two sides of a rectangular triangle are known and have to calculate the third side.
- The students apply the Pythagorean theorem in solving a Geometry problem (exercise 4 page 51).

► **Activity 5 :** Homework

- Study of the proof of the Pythagorean theorem page 48.
- **Activity 1** for students to apply the Pythagorean theorem to calculate an unknown side of a rectangular triangle according to the inductive way of work followed in the application.
- **Activity 9** for students to apply the Pythagorean theorem to compute an unknown side of a rectangular triangle.

Assessment and Evaluation

(Assessment(s) before, during, and after the lesson)

- If all students are able to understand the Pythagorean theorem and apply it correctly to calculate the required length of a staircase.
- If all students are able to respond positively to homework.

Resources

(Educational material / equipment/ services/ facilities)

For the successful completion of the course is essential:

- Use of mobile phones with Hp reveal application.
- School Book.
- Computer/Interactive table.
- Worksheet, Picture.

Additional Information/ Comments

The above topic could be used by other lessons such as History, Art, Computer Science etc.

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ENZYMES LESSON PLAN

Lesson Plan Information		
Subject: Enzymes & chocolates		**Curriculum alignment:** Biology, Chemistry
Topic: Enzymes as catalysts play one of the most important roles in biology. How enzymes function as catalysts? How enzymes lower the activation energy resulting in an increased rate for biochemical reactions?		**Duration: 4 hours**
Grade Level: Secondary School	**Age Range: 12-15**	**Language: English**

Prior Knowledge and Skills Needed
(Prior knowledge is the knowledge the learner already has before they meet new information)

- Presentation skills
- basic ICT skills
- previous knowledge on how cells function (homeostasis, extraction of energy from food, waste, reproduction)
- basic knowledge of the molecular structures and their primary functions

Objectives
(*Learning outcomes are what students are expected to learn after completing the lesson plan)*

Students should be able to understand:
The role of enzymes in biological processes, the relationship between activation energy and reaction rate in an enzymic reaction

In terms of biology and ecology:
Learners should have the ability to comprehend in a higher level the role of enzymes, how they work, under which conditions, and they could also make their own chocolates with liquid centers that are made with an enzyme called invertase.

Instructional Strategies
(Teacher approach to helping students achieve the learning objectives and meet their needs)

How can I help my students reach the learning goals?

Through:
team work and group discussion during the hands-on experiment
problem based learning and project-based learning

Learning Activities
(Opportunities provided for students to develop knowledge and skills of the learning objectives)

To introduce the topic I will use …

Learning Activities:

Activity 1 (Lesson 1):
In the first lesson teacher will ask from his/her students to find information on the web for the enzymes. He/she will then ask them to discuss between them and create short presentation (in groups of 3-4) about a specific enzyme or a specific function.

Activity 2 (Lesson 2):
The second lesson will be a presentation in the classroom, the teacher will present the basic enzymes' functions along with how they work. The teacher will also show in the classroom a video (using VR goggles) of an enzyme and how it looks like in microcosmos and the way it functions (indicative video: https://www.youtube.com/watch?v=IhSV5vvge5c). With the help of Virtual Reality students will have the opportunity to comprehend the term 'activation energy', enzymes' role in speeding up the chemical reactions without being used in the chemical reaction.

Activity 3 (Lesson 3):
Make soft-centered chocolates. Invertase (an enzyme that takes the molecular of sucrose that is a di-saccharate and breaks it into the two different mono-saccharates which are glucose and fructose, it works best in quite acidic conditions and in 60º Celsius) is added (1 or 2 drops) with a control measure on the sugar cubes. In another sugar cube we add a couple of water drops. After this, we cover both sugar cubes with melted chocolate.

Activity 4 (Lesson 4):
After a week, teacher along with his students visits the laboratory and cut-off the chocolate they made. They can now see that the chocolate in which invertase was used has a runny consistency in contrast with the one that we put water on it. With this experiment, students have the possibility to watch how enzymes are used in the everyday life and in food technology.

Assessment and Evaluation
(Assessment(s) before, during, and after the lesson)

The assessment is present in various stages throughout the 4 activities (each takes one lesson).

Resources
(Materials / Equipment)

What do I need to have in order to complete this lesson?

For this lesson you will need:
- Laboratory
- Control Measure
- Melted chocolate
- Sugar cubes
- Invertase (enzyme)]

Extensions

What can I do after the lesson is finished?
Students are encouraged to go home and try the same with sugar fondant. They will first see the sugar fondant's consistency and then with the help of both invertase and melted chocolate (that covers the sugar fondant), the consistency (after a week) will become runnier and more squidgy. They can also experiment with chocolate-cover cherries (use maraschino cherries so that invertase will liquefy sugar)

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HUMAN DIGESTIVE SYSTEM

Student's worksheet

Names: ……

Class: ……

Aims: to analyze the parts and functions of human digestive system; to explain the process of digestion and absorption of nutrients.

1st task - read the following text about digestion with your group.

Human digestive system consists of mouth together with teeth and tongue, pharynx, esophagus, stomach, small intestine, large intestine, and rectum. In addition, there are accessory organs of digestion, such as liver and pancreas, which secrete gastric secretions. The main function of digestive system is to break down food into smaller components, until they can be absorbed and assimilated into the body.

2nd task - observe the parts of human digestive system by using a model. Open at least one model for your group. Please make sure that there is Sketchfab app downloaded in your device(s). To open the model, scan the following QR-code:

Observe the model in augmented reality. To do that, you need to click on the AR (Android devices) or (Apple devices) button.

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Open the same model in 3D in an another device. Do not click on the AR button. You should have the following views:

Model in 3D

Model in augmented reality (AR)

Observe closely, where the digestive system's organs are located (the number in brackets indicates where the organ is located in 3D model). Observe the AR model from different sides, try to move inside the model. Use the 3D model to get the information about the following organs:

esophagus (1); *stomach* (2, 3, 7); *liver* (4, 5); *gallbladder* (8-10); *small intestine* (6, 13, 14); *duodenum* (6); *pancreas* (11); *large intestine* (12, 15-20); *rectum* (19); *anus* (20)

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Next, you have to read the following text about how food is digested.

Digestion begins already in the **mouth,** where the food is chewed. Moreover, breaking down the carbohydrates by an enzyme called amylase, takes place here.

The food now moves forward to **pharynx**, then to **esophagus**, and then to stomach. There is no digestion in the pharynx and esophagus.

The process of digestion continues in the **stomach**, where the food is mixed with gastric acid. The enzyme pepsin begins the digestion of proteins there. The food moves forward to **duodenum**, where digestion of lipids takes place. The digestion of lipids is mediated by gastric enzymes and bile acids. The bile acid is secreted by the **liver.** In duodenum, the digestion of proteins and carbohydrates continues. The **pancreas** plays an important role here, by secreting some gastric enzymes.

Duodenum is actually the first section of the **small intestine.** The digestion of proteins, lipids and carbohydrates ends in the small intestine. The absorption of nutrients also takes place there.

The remaining undigested food accumulates in the large intestine. The remaining food is semi-solid in the beginning, but changes to solid because of the absorption of water. The remaining solid waste is removed by the **anus**.

Divide the tasks in your group and draw the following (use the text you just read and the AR model):

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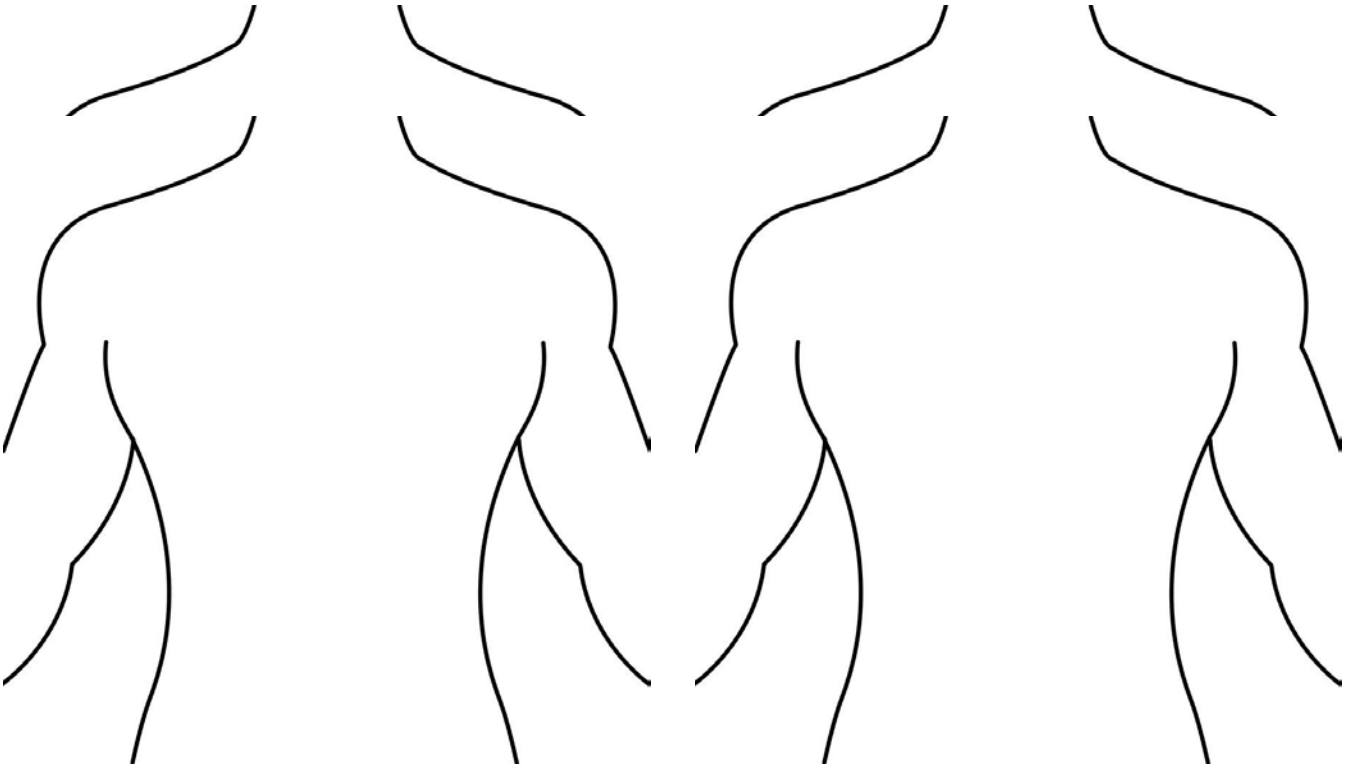
a) digestive organs in which the food passes through (frontal view)

b) digestive organs in which the food passes through (back view)



c) digestive organs in which the food is being digested

d) digestive organs in which the food does not pass through

3rd task - answer the questions orally so that all of your group members have the opportunity to speak. Then write down your answers.

1. Which two organs are very important in digestion, but the food does not pass through them?

……..…….. and …….…….

2. In which organ does the absorption of nutrients take place?

…….

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3. Where begins and where ends the process of digestion?
The process of digestion begins in the ……...… and ends in the ……....

HUMAN DIGESTIVE SYSTEM

Teacher's worksheet

Aims: to analyze the parts and functions of human digestive system; to explain the process of digestion and absorption of nutrients.

Duration: 20-25 minutes.

Background information:

1) students must be divided into groups (3-4 members in each group);
2) Sketchfab app and a QR-code reader must be downloaded in the devices (Apple devices must use the camera to scan the QR-code, no additional QR-code reader needed).

Materials: printed student worksheets, devices (phones or tablets) - at least two devices and one worksheet for one group.

Tasks on student's worksheet:

1st task - students read about the digestion.

Human digestive system consists of mouth together with teeth and tongue, pharynx, esophagus, stomach, small intestine, large intestine, and rectum. In addition, there are accessory organs of digestion, such as liver and pancreas, which secrete gastric secretions. The main function of digestive system is to break down food into smaller components, until they can be absorbed and assimilated into the body.

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2nd task - students observe the parts of human digestive system by using a model. They need to open at least one model for their group. To open the model, they need to scan the following QR-code:

Model: https://sketchfab.com/3d-models/the-human-digestive-system-peristalsis-854775b61faa4825975180a2fc4092d7

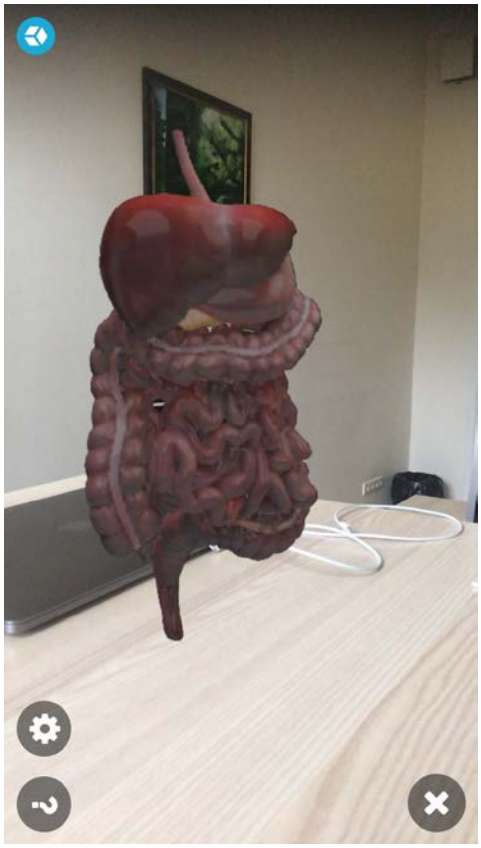
They need to observe the model in augmented reality. To do that, they need to click on the  (Android devices) or  (Apple devices) button. If somehow the model does not open after clicking on the AR button, then they should click on the settings and turn off the shadows ("AR Flood Shadow").

To open the model in an Apple device, camera must be used to scan the QR-code.

Students have to open the same model in 3D in an another device. They need to open it by

the same QR-code, but should not click on the AR button. They should have the following views:

Model in 3D



Model in augmented reality (AR)

Students need to observe closely, where the digestive system's organs are located (the number in brackets indicates where the organ is located in 3D model). They have to observe the AR model from different sides, and also try to move inside the model. Students should use the 3D model to get the information about the following organs:

esophagus (1); *stomach* (2, 3, 7); *liver* (4, 5); *gallbladder* (8-10); *small intestine* (6, 13, 14); *duodenum* (6); *pancreas* (11); *large intestine* (12, 15-20); *rectum* (19); *anus* (20)

Next, students have to read the following text about how food is digested.

Digestion begins already in the **mouth,** where the food is chewed. Moreover, breaking down the carbohydrates by an enzyme called amylase, takes place here.

The food now moves forward to **pharynx**, then to **esophagus**, and then to stomach. There is no digestion in the pharynx and esophagus.

The process of digestion continues in the **stomach**, where the food is mixed with gastric acid. The enzyme pepsin begins the digestion of proteins there. The food moves forward to **duodenum**, where digestion of lipids takes place. The digestion of lipids is mediated by gastric enzymes and bile acids. The bile acid is secreted by the **liver.** In duodenum, the digestion of proteins and carbohydrates continues. The **pancreas** plays an important role here, by secreting some gastric enzymes.

Duodenum is actually the first section of the **small intestine.** The digestion of proteins, lipids and carbohydrates ends in the small intestine. The absorption of nutrients also takes place there.

The remaining undigested food accumulates in the large intestine. The remaining food is semi-solid in the beginning, but changes to solid because of the absorption of water. The remaining solid waste is removed by the **anus**.

Then the students have to divide the tasks in their group and draw the following (using the text they just read and the AR model):

a) digestive organs in which the food passes through (frontal view);

b) digestive organs in which the food passes through (back view);

c) digestive organs in which the food is being digested;

d) digestive organs in which the food does not pass through.

Please make sure that every group member is involved in this task.

3rd task - students answer the questions orally so that all of their group members have the opportunity to speak. Then they write down their answers.

1. Which two organs are very important in digestion, but the food does not pass through them?

The liver and *the pancreas.*

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2. In which organ does the absorption of nutrients take place?

In the small intestine.

3. Where begins and where ends the process of digestion?
The process of digestion begins in the *mouth* and ends in *the small intestine.*