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

HOLOMAKERS PROJECT

Motivating secondary school students towards STEM careers through hologram making and innovative virtual image processing practices with direct links to current research and laboratory practices

Erasmus+ KA2 2017-1-PL01-KA201-038420

The Pilot Protocol

Pilot Protocol and Development of Evaluation Tools

Lead Partner: AIJU

Authors: Jose Carlos Sola

Circulation: *Public*

Version: *02*

Stage: *Final*

Date: *01.10.2019*

Contributions

Marek Rembowski (FMD)

Artur Sobczyk (WUT)

Rene Alimisi, Chrysanthi Papasarantou (Edumotiva)

Declaration

This report has been prepared in the context of the HOLOMAKERS project. Where other published and unpublished source materials have been used, these have been acknowledged.

Copyright

Funding Disclaimer

This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Table of Contents

Abstract

The HOLOMAKERS pilot protocol provides detailed information on how teachers are supposed to work with the students and apply from a pedagogical perspective the learning intervention in the class. It will also provide good practice examples in the form of scenarios. The tools for monitoring the learning interventions, documenting feedback, collecting qualitative and quantitative data to evaluate the learning intervention will be also described here. The HOLOMAKERS pilot protocol will be also available as OER.

Terms and Glossary

Hologram	Photograph that, illuminated by laser beam, looks three-dimensionality.
Holography	Photographic technique based on the use of coherent light produced by the laser, which allows to record and reconstruct three-dimensional images without using lenses.
Optics	Branch of physics that involves the study of the behavior and properties of light.
Light	Part of the electromagnetic radiation that can be perceived by the human eye.
Image	Visual representation, which manifests the visual appearance of a real or imaginary object.
STEM	Science, Technology, Engineering, Maths
STEAM	Science, Technology, Engineering, Arts and Maths
3D	Three dimensional

Chapter 1: **Introduction**

This pilot protocol allows following the necessary steps to implement the results of the HOLOMAKERS project in the schools.

This document provides guidelines and recommendations on how to carry out the implementation of holography for educational purposes in schools.

In Chapter 2 the teacher can find the necessary basic knowledge and how to use holography.

Chapter 3 details the pre-tests and post-tests to be carried out, as well as the direct feedback that is shown in each class that is implemented.

This procedure has been tested in schools in Spain, Greece, Poland and Italy, where the different partners of the HOLOMAKERS project have offered all the technical support and training resources so that the process of implementing holography in the classrooms has been successful.

It is important to highlight the need to follow the procedure properly so that the implementation of the holograms is successful. The formation of teams of students in an appropriate way, collecting their feedback, improving their motivation and learning should be the teacher's objective. In the same way, the evaluation process is also described.

RATIONALE & MOTIVATION TO USE HOMOGRAPHY IN SCHOOLS.

We are witnessing constant changes in the current world, and in the field of education, these changes are increasingly visible. students must become builders of their knowledge and builders of real and relevant solutions. School time is the most important educational period. students must create learning mechanisms, build Critical thinking knowledge and develop problem-solving skills.

The STEM professions (based on Science, Technology, Engineering, Mathematics) have a growing demand, but instead, students do not decide for these professions. HOLOMAKERS can contribute that STEM careers are attractive for students. The introduction of educational holography in technology subjects is one more resource for STEM subjects to be more motivating for students.

Keeping in mind that technology is really popular for new generations. The objective is to use holography for all students using student-centred pedagogies that favour students learning, their creativity, increasing engagement and real learning, improving a constructivist model and critical thinking.

Therefore, it is important to know how we can integrate the holographic technology into the teaching and learning process. This pilot protocol is a procedure to success, taking advantage of the use of technology to improve student learning.

Chapter 2: **Carrying out the learning intervention**

2.1 Selecting the students

Holomakers project aims at engaging school students (14-17 years old) that demonstrate low interest in STEM and keep distance from STEM related disciplines in innovative hologram, making practices following the Maker Movement trend in education, a global drive that encourages young people to be creative with technology.

Below you can find instructions on how to select the students that are going to participate in the Holomakers learning intervention.

Step 1: Inform all students about the HOLOMAKERS project, which focuses on the creation of holograms and invite them to express their interest in participating. Make a presentation of different examples of holograms to arouse the interest of the students. In addition, explain the "A" in the term STE**A**M (Science, Technology, Engineering, **ARTS** and Mathematics), since introducing Art into these subjects can help to attract more girls' interest and include gender considerations. Also point out that holography could be combined with other new technologies, such as Virtual and Augmented Reality, which will allow the realization of very creative and innovative activities.

Step 2: Assess students' interest and select the students that are more eligible to participate giving priority to those that demonstrate low performance in STEM related subjects and feel uncomfortable with STEM or think that STEM subjects are not related to real life and do not allow them to be creative.

Step 3: Then you must consider other criteria / conditions for the final selection (in Appendix A, you can find a survey to assess the knowledge and opinion of students). We must take into account students who add many characteristics that lead to poor performance and school failure.

Step 4: Make sure that girls and boys have equal opportunities for participation. STEM education must be gender inclusive and encourage girls to participate in ICT and STEM activities. Girls are often attracted by the "A" in STEAM and thanks to their communication skills, contribute to build a collaborative team. Boys and girls is proposed to work in mixed teams. It would be very helpful if at least one teacher in teachers' team is a woman since girls tend to feel familiar with teacher's example and gender.

Step 5: Form a mixed group of 15 students. This group will take part in the Holomakers learning intervention. The students should not necessarily be at the same age or belong to the same class. Keep a supplementary list in case some students cease to attend, for example,after the 1st project.

The selection of the students, through the selection criteria, is a reference tool and the teachers of the school will have the freedom to modify and adjust the criteria to what can be done in the school, but it is important to make sure that Students are not required to participate, characteristics of underperforming students have been considered by teachers and the selection did not happen mainly based on grades.

Next, we answer to possible questions that teachers may have:

What if a large amount of students express interest in participating in the project?

This is an absolutely positive indicator. More students can be exposed in the Holomakers intervention or workshops in the future. However, for evaluation purposes, the teachers can select 30 students (a relatively smaller number compared to the ones expressed interest): the ones with the lowest average performance in school. Depending on the criteria for selection they can select the 15 that are more eligible.

The names of the courses are not in line with our schools' curriculum.

This is very contextual issue. Teachers can replace the names of the courses and choose the number of STEM courses that will be taken into account.

I do not have an answer to all the questions. What should I do?

If the teacher can not address an answer or feels that it goes beyond his/her knowledge regarding students' profile...he/she checks the "I don't know" option. Many of these characteristics require a deeper sociological analysis/research. But this goes beyond the scope of the project.

Should I include the same number of girls and boys?

Equal opportunities for participation and expression of interest should be provided to boys and girls. It would be nice to have a mixed final team...but we are not looking for exact equal numbers.

2.2 Forming the teams

This is the stage that the group come together for the first time. At this stage, it is important to trigger the necessary mechanisms for the "group-development process", to actually compose the teams and to set a basis whereupon good relationships among the team members can be established. More precisely, this stage starts with icebreaking activities, setting the ground rules and explaining the process that the students will go through, composing the teams and filling in the pre-survey. All these steps are important before the introduction to the creation of holograms.

The time appear in brackets is the suggested average time that should be allocated in each step. Bare in mind that you can modify the time, merge or skip some steps, based on your needs. *For instance, icebreaking activities may not be necessary if the group members know each other well.*

Step 1: Icebreaking

Icebreaking activities constitute a frequently used practice to start getting students integrate and connect with one another and engaged with the topic of the session. They can play an important role towards the enhancement of group building and the stimulation of the participation.

Icebreakers can potentially:

- Help students get to know one another.
- Help students to integrate into a group.
- Establish a welcoming atmosphere and make everyone feel comfortable.
- Trigger mechanisms towards collaborative learning.
- Encourage group-building.
- Establish a positive atmosphere for learning and participation.
- Help students get a sense of their common goal for accomplishment.

Below you can find selected ice-breaking activities that can be easily implemented in the class.

Icebreaking activity 1:"Present yourself"

Ask students to introduce themselves. Each student present his personal hobbies and interests, his previous project experience and his/her expectation from the Holomakers project.

Icebreaking activity 2: "Small talk/Interview" (alternative of activity 1)

Divide the students into pairs. Ask them to take 3-4 minutes to interview each other. Each interviewer should identify 2-3 interesting facts about their partner. Bring everyone back and ask everyone to present his/her partner to the rest of the group providing key information and the 3 interesting facts.

Icebreaking activity 3:

Ask students to choose a team name, motto and logo. Give them a short of time (about 10') to complete this activity. If time is not sufficient, this process can be continued for the first 4 lessons. This triggering activity enhances team building and collaboration. Starting lesson with team name discussion is cultivating a cooperation mentality in the class.

Icebreaking activities can set a basis whereupon a learning intervention can start but they cannot guarantee for sure the success or the achievement of the learning outcomes.

Step 2: Create a set of norms or ground rules

It is also important to create **a set of norms or 'ground rules'** that will reflect the accepted behaviour in a group. This will help better implementing the learning intervention in the class. The best way to create a set of rules in a classroom is to decide them as a group. Make sure that everyone contributes and makes suggestions. You can then document the rules that you all agreed in. The documentation will help possible future reference to the rules.

Rules may revolve around the following topics: project tasks and outputs, time assigned to each project, group/classroom behavior, safety guidelines about the lasers that will be used during the creation of holograms, good practices at the time to work in the laboratory. It is important to set rules that will enhance collaborative learning and meaningful interaction among the group members. It is also important to ensure that the appropriate rules have been set for establishing a positive atmosphere for peer learning and ideas sharing.

Lab safety rules require special attention and you should play a key role in establishing and communicating them. Teach students to be safe while using lenses and lasers, as well as the optics instruments that are required.

As part of this stage you should also explain deliverables, time assigned to each project and students' responsibilities:

- Students should keep a record of the entire process (ideas, different scenarios in which to frame the hologram, key difficulties, presentations, suggestions etc).
- At the end of each project they will be encouraged to evaluate their work (self-assessment) and to provide feedback to the other teams as well.

Give us an example of a norm

A simple norm for the whole group (that includes teachers and students) that denotes the importance of focusing on the process might be:

"Learn together, fail together, try again together"

What happens if the rules and the norms are not followed?

Take time at the end of the session to point out students that are utilizing the rules set. If needed, spend some time to discuss with the students that do not respect the set rules. One to one discussions may help you understand the reasons underpinning their behaviors.

Step 3: Composing the teams

Given that the projects require work at a computer station, we recommend forming teams of two or three students. Larger teams may not be very effective; in addition, in large teams there is always the risk of having some members that adopt or hold relatively passive roles. Moreover, it might be more challenging for the team members to deal with misunderstandings.

However, you should also bear in mind that with only two people on a team, there may not be a sufficient variety of ideas and approaches to problem solving. In addition conflict resolution can be challenging. Your role will be important in order to ensure that the teams function well. Opening

up the discussion to the whole class may also be a good practice for generation of feedback and new ideas (when needed).

Suggestion

You can either let the students choose their partners and form the teams or you can randomly compose the team undertaking playful techniques like the one that follows:

- Prepare 15 small papers.
- Write the word "team" on each paper in different colour: 3 red, 3 blue, 3 magenta, 3 green, 3 orange.
- Fold small papers, put them in a box and invite each student to pull one.
- The teams are defined by same coloured papers. In this way, the teams gain their first name e.g. red, blue, magenta, green and orange.

The aforementioned practice is a suggestion; there are many other creative ways to divide students into groups. More ideas towards this direction can be found online [see https://sites.google.com/a/lavaridge.net/staff-development/home/creative-grouping-strategies].

Step 4: Fill Pre-survey

Before engaging the students in holograms projects, it is important to gain an insight into their views, interests and perceptions related to STEAM education. A pre-survey, that takes the form of a questionnaire aims at offering insight on these matters (see appendix A). More precisely, the questionnaire allows us to better understand students' profiles and perceptions regarding STEAM subjects, accumulated experiences and skills. You may need to provide clarifications before students start filling in the questionnaires.

Why is it called pre-survey?

This is due to the fact that a **post-survey** will be also completed by the students when the pilot period will be over. The pre and post –survey will allow the Holomakers team to see if the suggested learning intervention help students adopting more positive attitudes towards STEAM-related disciplines, improving their skills and performance in this area.

2.3 Introducing the creation of holograms

This is the stage in which he introduces his students to the techniques of creating holograms. It is important to introduce them in these techniques through playful and experiential forms.

How can I introduce my students to the basics of creating holograms?

- Show them examples of selected holograms and let them touch the product or artwork. Ask them to describe the object and think-aloud.
- Prepare a presentation (with embedded pictures and videos) that describes how to develop holograms.
- Open a discussion about possible implementations of holography and in which scenarios to work.
- Compare holography with other technologies such as Virtual and Augmented Reality. Help the students through these comparisons to learn what is hologram and what is not.
- Encourage your students to learn how holograms are made through the projection of laser light and how it is reflected in the different lenses.

Another useful technique to awaken the interest of students in the creation of holograms is to share with them inspiring stories where holography positively impacted the lives of people, society and more.

Task (Optional)

Given the available time you may consider encouraging your students to conduct a one-page research about holography. Make sure that during the next session the students will have the chance to present their findings. Give 5-7 minutes to each team to present their work.

Then, you can discuss with the students the benefits of holography in real life. It is very important to mention that one of the latest changes in product development is the impact of holography on the rapid creation of virtual prototypes. The discussion can focus on the following important aspects of holography:

- Time-to-Market: holography how is applied to solve real needs? In which domains?
- Mitigate Risk: be able to verify a design before investing in the industry. The visualization of a prototype ready for production generates confidence before making large investments.
- Get the feeling: a thing that cannot be obtained from a simple image, can take life through holography.

2.4 Introducing the holography in interdisciplinary projects

Before introducing the project in the class, make sure that you have exposed yourself to it. This is important in order to better understand the challenges that the students may encounter. And to plan accordingly. In addition, no matter the estimated time for project implementation and given your students' strengths and weaknesses you will get a feel for how long it is going to take. In case full pre-engagement is not possible (i.e. due to the complexity of the project) just make sure to identify discrete sections that you can do in advance. The Holomakers online class offers a range of collaboration tools. It is a good idea to share your ideas, questions, concerns, problems with the enrolled members.

Moreover, ensure that the students are aware of the process that will be followed. Explain to them what the outcome of a project might be: a product, a presentation, a service (i.e. teaching other students) etc. This gives a sense of purpose from day one. You can then provide more project-specific information.

Step 1: Project description

For each project introduce the main goal. Show to your students the object to be created. This can be done (depending on the project) through a demonstration of

- A hologram pre-constructed.
- A real-life object
- Authentic pictures/videos that demonstrate the object or the holographic process

In case you have completed the project, you can show your own hologram. Apart from the hologram, it is equally important to talk about the characteristics of the object (materiality, colour, texture and more). You might also want to show other students' work.

It is of great significance to make the project relevant and to connect it to what the students have learnt or were learning in the school. Use driving questions to help your students identify connections to the school curriculum and their everyday experiences. It is equally important to stress the interdisciplinary nature of the project as well as to establish links (if possible) with current research, entrepreneurial and artistic practices. The videos that have been developed in the context of the Holomakers project will support this task.

Step 2: Breaking down the object and identifying characteristics

In this stage, it is important to encourage your students to reflect upon the object to be holographed considering also practical aspects inherent in the design. Give students some time to document their ideas related to the project. Help them define the model to be created. Encourage them to free their imagination and argue about the best way to proceed with the design (to decide upon the material, the texture, the colour, the correct angles and positions). You can then build on their own ideas and chain them into coherent lines of thinking and proceeding with the creation of hologram.

You may encourage the teams to present their paper-based solutions and ideas in the class and get feedback by their fellow classmates. More precisely, you may consider asking the representative of each team to make a three-minute presentation of the paper-based model. Encourage the students to articulate their thoughts freely, without fear of embarrassment and through probing questions ensure that all the teams have reached a common understanding.

Step 3.1: Instructions and familiarization with the software (for Computer Generated Holograms)

Having reflected upon the scenario of the project, it is now time to help your students start developing strategies for implementing the project. This is the stage where you should deliver the worksheets to the students and provide them with the necessary explanations and help them go through the worksheet. For example, you can get students actively responding to the material they are studying through probing questions. You can then make a public demonstration of Octave software and familiarize your students with the basic features. The Holomakers Technical Reference Guide, in O1 will guide you through all the important aspects that you need to know in order to familiarize your students with the basic features of the selected computer aid program and help them smoothly engage in the creating hologram process. This step will be more project-specific as the students become familiar with the computer aid design software.

Step 3.2: Instructions and familiarization with the Holokit (for physical hologram making)

In the case of physical hologram making, make sure that the students have enough time to assembly the Holokit. You can distribute the localised versions of the manual (or the how-to videos) to support their hands-on work. A demonstration of the Holokit will be needed in the beginning together with some explanation of the components. Show to the students how to place the film between the plexi glass plates and ensure that they have understood all the steps of the hologram recording process. Provide good tips and help them allocate roles within their groups. The Holomakers worksheets in O3 will guide them through all the important steps that they need to know in order to successfully engage in the hologram recording process.

2.5 Project presentations

It is important to let students know that their work will be displayed publicly through various means. When students know that the work they are creating in a project will be displayed publicly, this usually changes the nature of the project from the moment they start working – because they know they will need to literally 'stand by' their work, under scrutiny and questioning from family, friends, and other interested individuals. This inspires a level of ambition and commitment much greater than is fuelled by the incentive of 'achieving a good performance. In addition, the audience gets to see what is going on in the school, thereby providing an opportunity to strengthen the bonds between the school and community.

- **Presentations in the class**
  When the project is over, the students can be encouraged to present their work in the classroom. Each team can be given 6-10 minutes to introduce the way they approached the project, refer to the roles within their team and how they worked together in completing the project, explain the technical challenges they faced, talk about the overall experience, evaluate their work and present the final outcome of their work. The other teams (that comprise the audience) can provide their feedback.

- **Online presentations**
  Students' works can be also put online. Short documentations combined with pictures and videos (if possible) can be used for the demonstration of their work through the Holomakers website. These publications can be replicated through social media.

- **Presentations in the context of other school events**
  The teachers may consider other possible opportunities for presenting students' work in the general public (i.e. school festivals, specific faires, school bazaars and more).

Post feedback generation matters!

Don't forget to give the questionnaires after the survey to your students. This will allow teachers to see if there is any change in their students' attitudes towards STEAM related disciplines and / or their performance. See more in Appendix B.

2.6 Interactions and Extensions

Briefly, the teacher in acts as a facilitator encouraging participants to deal with failure and learn from it. He/she invites them to point out what they found compelling and interesting in their work. Projects are extended learning opportunities, and not just for students. Your own enthusiasm will be required when students hit blocks and dead-ends. It's important that you are personally curious about the project's outcome, that you will learn new things from it.

In general,

- treat students with respect and caring
- provide the relevance of information to be learned
- use active, hands-on student learning
- vary their instructional modes (multimodality matters)
- provide frequent feedback to students on their performance
- offer real-world, practical examples
- draw inferences from models and use analogies
- provide clear expectations for the selected projects
- create a positive class environment
- communicate to the level of your students
- reflect on your own classroom performance in order to improve it

Extensions

During the phases 2.3 and 2.4, students is proposed to be encouraged to help each other and act as multipliers. In this way they are allowed to become experts by teaching other students (peer-learning), gain self- esteem and feel excited by their participation to a project that is meaningful to them. Students also need to trust each other and themselves and be able to understand the weak points of their results and improve them. HOLOMAKERS project is focusing on fostering students' skills such as collaboration, time management, problem solving and learning through failures. Do not forget to encourage students to take decisions for themselves throughout the whole project implementation period.

Chapter 3: **Evaluation of the learning intervention**

In this chapter, we will explain the evaluation of the learning intervention in schools on the subject of STEM. The information provided by the evaluation of the learning intervention helps the team of teachers to have relevant information to critically analyse their own educational intervention in STEM subjects and make decisions about it.

To do this, you must verify the information provided by the continuous evaluation of the students with the proposed educational actions. Therefore, the programming of the teaching process and the intervention of the teacher as an animator of this process, the resources used, the spaces, the programmed times, the criteria and evaluation instruments, the coordination ... That is to say, everything that is limited to the scope of the teaching-learning process is evaluated.

On the other hand, the evaluation of the teaching team as a whole allows to detect factors related to the functioning of coordination, personal relationships, the work environment, organizational aspects, among others, which are very significant elements in the operation of the centres.

To carry out the evaluation of the learning intervention, questionnaires are used. The questionnaires are specifically aimed at students and teachers. To facilitate the evaluation, the questionnaires will be passed online. In the case of students, they must complete two questionnaires, one prior to the learning phase and one subsequent.

See Annex A to view the prepared survey.

3.1 Collecting feedback from the students

Both the questionnaires prior to the learning intervention and the subsequent questionnaires will be carried out online. Each teacher will explain to their students how to proceed to complete each test.

3.1.1 Pre-test

Students will be asked to complete the pre-test before the intervention. The pre-test aims to explore the experiences, opinions, skills and points of view of students on STEAM issues. The student survey comprised five sections: "STEAM interest", "School experiences", "Knowledge in the field of science (optics)", "Perceptions", "Future plans and views on careers / studies".

3.1.2 Post test

After the students complete the course, the teachers will compile the comments that students make through the post-test surveys. The final objective is to analyse if students have increased their knowledge in any specific STEM subject. Also check if the course has aroused more interest in the field of STEM activities and how students have assimilated that STEM skills will be very useful for their future work.

The in-class feedback form is available in the Dropbox and in the appendix of this report Collecting feedback from teachers

The participating teachers will complete an online questionnaire also, with the aim of obtaining comments related to their experiences.

The teachers will also carry out an observation of the process, to correct deviations and they are guides of the students adapting the activities for their adequate development, in the case that is necessary.

Chapter 4: **Ethical issues**

Introduction

In principle, the design and development and introduction of HOLOMAKERS in an educational/personal development tool for childhood sectors in society will raise a number of ethical challenges that require careful consideration. Such challenges are particularly relevant in two phases of the R&D process. In the research process, the definition and specification of user requirements, particularly where the child end user is involved, may necessitate the gathering of information through specific data generation techniques such as questionnaires and or interviews. Such methods may involve the gathering of personal data for analysis as well as views and opinions as to the technology to be developed in an anonymous manner. In such instances, the relevant laws relating to data protection in each country in which the research is to be carried out will apply. In the development process, the testing and demonstration of prototypes amongst children users may also require the generation of data through specific data generation techniques as mentioned above and may also involve the observation of users as they interact with the technology. Once again, any data of a personal nature which is generated, and the way in which it is used, (including storage and retrieval), must adhere to the relevant data protection laws which are applicable.

Ethical Issues and the HOLOMAKERS Project.

The potential ethical issue in project HOLOMAKERS relates to the use of the application when used by the teaching professionals as an educational tool to develop/improve skill sets. Teaching professionals are governed by existing legislation with respect to privacy of information. However, and with respect to the research to be carried out in HOLOMAKERS, the consortium will assess the importance of potential ethical issues, such as privacy and security of information, and put forward recommendations as to appropriate protocols and procedures to be adopted when using the HOLOMAKERS application as an educational tool in order to ensure that the privacy and integrity of the individual is respected.

The Schools in charge of carrying out the implementation activities with children in will fulfil the national legislation in Personal Data Protection. The organisations participating in the project will fulfil with the Data Protection legislation in each country, for this reason, the consortium will guarantee the protection of the personal data obtained during the testing and evaluation activities carried out with the samples of children in participant schools.

Data Protection and the Right to Privacy and Informed Consent.

Since project HOLOMAKERS aims to develop the use of holography which has been tried and tested, it will be necessary to gather information on what users would expect from such a technology and how they interact with it.

The consultation process as well as testing and demonstration phases will involve pilot schools. Informed consent will be obtained prior to consultation and all individuals will have the right to remain anonymous. Furthermore, the consortium recognises the importance of limiting the potential for intrusiveness and the need to respect the appropriate ethical standards when collecting any data which may be inferred from emotional response. Once again, if such instances should arise during the HOLOMAKERS consultation process, then informed consent will be sought and respect for anonymity guaranteed as required by the regulatory framework in place.

The ethics committees of each Centre are available for consultation on any issues relating to the application of rules and obligations and their correct and appropriate interpretation.

With respect to legislation, consultation will be carried out taking the relevant legislation into account.

Although the general ethical principles prevalent in the European Union will be considered, it shall also be noted that ethics might differ from one local community to another. Therefore, interaction with local entities is fundamental in this process.

Furthermore, the HOLOMAKERS Project looked at a wide range of consultation instruments which include the following:

- Charter of Fundamental Rights of the EU
- Directive 95/46/EC on the protection of individuals with regard to the processing of personal data and on the free movement of such data.
- UNESCO Declaration on the responsibilities of the present generation towards future generations
- UNESCO Declaration of Principles of Tolerance
- Ethical Guidelines for Educational Research, fourth edition (2018)

In addition to this:

1. Students will not be pressured to perform the tests.
2. Privacy will be ensured at all times by the researchers. As well as anonymity and confidentiality.
3. It will be evaluated according to the age of the students.
4. The data collected will be treated in an aggregated manner, guaranteeing the anonymity of the participants.

Appendices

Appendix A

Questionnaire for the students

Name of student: …….

Gender: Male | Female

Age: 13 | 14 | 15 | 16 | 17+ years old

Pilot site: Greek | Italian | Polish | Spanish

Stage: Prior to the workshop | After the workshop

STEAM interests

How interesting are the following subject areas to you? Mark the number that relates to how interesting each subject area is to you. Only one answer can be selected.

1=Boring, 2=Somewhat Boring, 3=Somewhat interesting, 4= Interesting, 5=Very Interesting

	Boring (1)	**Somewhat Boring (2)**	**Somewhat interesting (3)**	**Interesting (4)**	**Very interesting (5)**
SCIENCE [1]to me is					
MATH [2] to me is					
ENGINEERING & TECHNOLOGY [3] to me (is)					
ARTS & CRAFTS [4] to me (is)					

[1] ***Science:*** *Representative subjects (Physics, Biology, Chemistry,…). It includes the study of basic laws governing the motion, energy, structure, and interactions of matter. This can include studying the nature of the universe.*

[2] ***Maths:*** *is the science of numbers and their operations. It involves computation, algorithms and theory used to solve problems and summarize data. Subjects in the field of Maths: Algebra, Geometry…*

[3] ***Engineering and Technology****:* ***Engineers*** *use math, science, and creativity to research and solve problems that improve everyone's life and to invent new products. There are many different types of engineering, such as chemical, electrical, computer, mechanical, civil, environmental, and biomedical.* ***Technologists*** *implement the designs that engineers develop; they build, test, and maintain products and processes*

[4] ***Arts:*** *a diverse range of human activities in creating visual, auditory or performing artefacts (artworks), expressing the creator's imaginative or technical skill, intended to be appreciated for their beauty or emotional power (i.e. painting, grafitis, crafts, music,…)*

School Experiences

Mark the answer that is true to you. Only one answer can be selected.

How often do you do the following in your class?

	I do not know	Never	Rarely	Sometimes	Frequently or Always
You get examples of how the things you learn in Math & Science matter in the real world					
You get involved in hands-on and practical activities using also math and/or science					
You get involved in Math, Science or Technological activities that integrate Arts.					

Knowledge in the field of science (optics)

Read the statements below. As you read you know whether you can you do the following tasks and provide the following explanations. Only one answer can be selected.

	No	**Maybe No**	**Maybe Yes**	**Yes**
I can mention at least 3 practical applications of optics (branch of Physics)				
I can mention at least 3 optical instruments				
I can describe the phenomenon that makes the butterfly' s wings so colorful.				

PERCEPTIONS

Read the statements below. As you read the statement you will know whether you agree or disagree. Mark what describes better how much you agree or disagree. Only one answer can be selected[5].

[Strongly Disagree (1), Rather Disagree (2), Neither Agree nor Disagree (3), Rather Agree (4), Strongly Agree (5)]

	Strongly Disagree	**Rather Disagree**	**Neither agree not disagree**	**Rather Agree**	**Strongly Agree**
	1	**2**	**3**	**4**	**5**
I am more motivated when through STEM subjects I get involved in art-related activities					
Knowing how to use math and science together can allow me to make useful and creative things					
Knowledge of math and science can help me understand how the world works					

[5] Directions: Students will complete the questionnaire online via computers. This question is Likert scale with the following choices: Strongly Disagree (1), Disagree (2), Neither Agree nor Disagree (3), Agree (4), Strongly Agree (5)

FUTURE PLANS & VIEWS ON STEM CAREERS /STUDIES

Read the statements below. As you read the statement you will know whether you agree or disagree. Mark what describes how much you agree or disagree. Only one answer can be selected.

[Strongly Disagree (1), Rather Disagree (2), Neither Agree nor Disagree (3), Rather Agree (4), Strongly Agree (5)]

To what extent do you agree with the following statements?

	Strongly Disagree	**Rather Disagree**	**Neither agree nor disagree**	**Rather Agree**	**Strongly Agree**
	1	**2**	**3**	**4**	**5**
I would like to continue my studies at university level in an area that is related to Science, Technology, Engineering and/or Maths					
I am interested in careers that involve using science and/or Maths					
I will need STEM skills in my future work					
I would like to do creative and innovative things in my future work					
I would like to be involved in research activities in STEM in the future					

Appendix B

Instructions

This questionnaire is for all teachers/educators that participated in the Holomakers project. We are interested in receiving your feedback and learning more about your experience from the 1st Holomakers pilot workshop.

Your responses are voluntary and confidential. If there is a question you do not wish to answer, simply skip it. We hope you will answer as many questions as possible. No individual teachers or their schools will be identified in any reports. This questionnaire should take approximately 15-20 minutes to complete. Most questions can be answered by marking the one most appropriate answer.

Thanks again for completing this questionnaire. Your help is greatly appreciated.

Teacher profile

Name:……..

Subject you teach: ……

Years of teaching experience (*Only numbers may be entered in this field*): ….

Pilot site: Polish… Greek… Spanish… Italian…

The Holomakers workshop in your school/educational organization

Number students involved ….. girls … boys…..

Number of teams: …….

Number of students that drop out ……..

Reasons for drop out (open question- *Ignore this question if you did not experience any drop-out*):
……
……
…….

IMPLEMENTATION

How many hours did you spend approximately for each activity? *Only numbers may be entered in these fields*

Activity 1: Physical Experiments …..
Activity 2: The cultural artefact …..
Activity 3: The oxymoronic sentences …..

Was the available time (2-3 months) adequate for carrying out the 1st pilot phase?

Choose one of the following answers

Yes | No

The first activities were supposed to familiarize students with computer generated holograms. Was this aim fulfilled?

Choose one of the following answers

Yes | No

Do you have any comments regarding the three projects (*Open question*):……
……
……..

What were the main difficulties/challenges that your students faced (if any)? (select **up to three** or **enter your own comment**).

Check any that applies:

- No difficulties/challenges
- Technical difficulties (related to Octave software)
- Technical difficulties (other)
- Organizational issues/ infrastructure
- Time constrains
- Lack of team spirit/ collaboration
- Lack of resources
- Students' lack of interest/motivation
- Lack of support from the Holomakers team
- Your own lack of comfort, knowledge or training in holography/CGH
- Other:……
  ……..

What effect did these challenges have on the implementation of the learning intervention?

Choose one of the following answers

Serious effect | Moderate effect| Slight effect | No serious effect | Not applicable

Students' progress / achievements

How many students completed the tasks?

Choose one of the following answers

All of them | Most of them | Half of them | Less than half | None

How was students' collaboration during the 1st pilot?

Choose one of the following answers

Excellent | Very good | Good | Fair | Poor

Students' reactions

Please briefly refer to students' reactions based on your observation (*open question*):

……
……
…….

Students' attitudes/ behaviours

To what extend do you agree with the following statements:
Choose one of the following answers

Strongly agree | Agree | Neutral | Disagree| Strongly Disagree

After this workshop it is likely that most of the students

Please choose the appropriate response for each item:

	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Have improved their collaboration skills	○	○	○	○	○
Have improved their problem solving skills	○	○	○	○	○
Have improved their performance in STEM	○	○	○	○	○
Have been motivated towards understanding new scientific concepts and ideas	○	○	○	○	○
Have a more positive attitude for STEM subjects	○	○	○	○	○
motivation and interest in STEAM have been enhanced	○	○	○	○	○
Are more confident and ready to take new initiatives	○	○	○	○	○
Have enhanced self-image, self-esteem	○	○	○	○	○

Support and teaching resources

The educational resources that you were provided with (for carrying out the three activities) were

Choose one of the following answers

Very useful | Useful | Somewhat useful | Not at all useful

The support from the project implementation team was

Choose one of the following answers

Very useful | Useful | Somewhat useful | Not at all useful

I was well-equipped to support my students during the project implementation stage

Choose one of the following answers

Strongly Agree | Agree | Neutral | Disagree| Strongly Disagree

In overall

To what extend do you agree with the following statements:

Please choose the appropriate response for each item:

	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
I am satisfied with the way this workshop was carried out.	○	○	○	○	○
The Holomakers learning intervention offered me opportunities for professional development and skill-building (both from a technical and a pedagogical perspective)	○	○	○	○	○
Holomakers practices can set a basis whereupon low interest in STEM disciplines can be tackled	○	○	○	○	○
Holomakers practices can help linking STEM to creative, artistic, hands-on practices	○	○	○	○	○
Holomakers practices can help linking STEAM to real life and research/scientific practices	○	○	○	○	○

How can we better support you in the future? Do you have any suggestions for improvement or any comments to raise? *(open question)*

……
……