Partnerships for Science Education

Project Number: 101006468

Project Acronym: PAFSE

Project title: Partnerships for Science Education

3D PRINTING TO ADDRESS PANDEMIC CHALLENGES

INESCTEC

JULY 2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006468.

Context and relevance for public health education

Additive manufacturing (AM), broadly known as 3D printing, is transforming how products are designed, produced, and serviced in public health. “AM enables on-demand production without dedicated equipment or tooling, unlocks digital design tools, and offers breakthrough performance and unparalleled flexibility across industries”.

Recent advances on 3D printing in healthcare have led to lighter, stronger and safer products, reduced lead times and lower costs. Also, custom parts and objects can be tailored to each patient and each situation. Medical applications for 3D printing are expanding rapidly and this technology is expected to revolutionize health care. The application of 3D printing in the medical sector can provide several benefits, such as the customization and personalization of medical products or equipment. However, literature refers that knowledge remains one of the greatest barriers to AM's wider adoption. So, how we leverage the potential of AM to drive innovation is a mandatory topic in science/technology curriculum.

The scenario supports science and ICT teachers in exploring 3D environments using updated scientific/technical evidences. The learning experience supports youths in understanding and reach high-level comprehension on how STEM (science, technology, engineering, mathematics) may contribute to address these issues and contribute to evidence-based personal decision-making.

Estimated Duration

7 classes of 40-45 minutes (lesson 1 – lesson 7)
4 sessions of 40-45 minutes for supplementary learning activities and school project (session 8 – session 11)

Prerequisite knowledge and skills

Basic ICT notions

Classroom organization requirements

ICT classroom with access to computers and a 3D printer.

To carry out the research project, students will work in groups of 4 or 5 elements. It is necessary to have a computer/tablet with internet access.

Content glossary

Additive manufacturing. Additive manufacturing is the process of creating an object by building it one layer at a time. It is the opposite of subtractive manufacturing, in which an object is created by cutting away at a solid block of material until the final product is complete. Technically, additive manufacturing can refer to any process where a product is created by building something up, such as molding, but it typically refers to 3-D printing.

3D Printer. A machine allowing the creation of a physical object from a three-dimensional digital model, typically by laying down many thin layers of a material in succession.

3D Environment. 3D environment is the generation of realistic computer-controlled digital settings for games, film, architectural renderings, and advertising using specialized computer software.

3D printing process. 3D printing, in full three-dimensional printing, in manufacturing, any of several processes for fabricating three-dimensional objects, is the process of layering two-dimensional cross sections sequentially, one on top of another. The process is analogous to the fusing of ink or toner onto paper in a printer (hence the term *printing*) but is actually the solidifying or binding of a liquid or powder at each spot in the horizontal cross section where solid material is desired.

Collaboration. A recognized relationship among different sectors or groups, which have been formed to take action on an issue in a way that is more effective or sustainable than might be achieved by the public health sector acting alone.

Equity/equitable. Equity means fairness. Equity in health means that peoples' needs guide the distribution of opportunities for well-being. Inequities occur as a consequence of differences in opportunity, which result, for example in unequal access to health services, nutritious food or adequate housing. In such cases, inequalities in health status arise as a consequence of inequities in opportunities in life.

Extruder. The extruder is a part of the 3D printer where material is ejected in liquid or semi-liquid form. It is deposited in successive layers within the 3D printing volume.

Filaments. Are *thermoplastics,* which are plastics (aka polymers) that melt rather than burn when heated, can be shaped and molded, and solidify when cooled. Filament is the heart of Fused Deposition Modeling (FDM) 3D printing. The filament is fed into the extruder, heated, and deposited in specific locations layer by layer.

Fused Deposition Modeling (FDM). The fused deposition modeling (FDM) is one of the additive manufacturing techniques which is largely used for printing of metal/thermoplastic materials with ease of design flexibilities. It has been utilized in the automobile industry, ranging from testing models, lightweight tools to final functional components.

Health. A state of complete physical, social and mental well-being, and not merely the absence of disease or infirmity.

Multimedia Contents. Multimedia refers to various types of media content, used together. Multimedia content includes text, graphic image files, audio files, video clips.

Polymers. A substance which has a molecular structure built up chiefly or completely from a large number of similar units bonded together, e.g., many synthetic organic materials used as plastics and resins.

Post-printing Process. Once the printing process is over, we proceed to our final stage of finishing, where an array of post-printing services such as cutting, folding, creasing, punching, die-cutting, perforating, laminating, foil stamping, embossing, addressing, inserting, sewing and collating are performed to meet product requirements.

Public health. An organized activity of society to promote, protect, improve, and – when necessary – restore the health of individuals, specified groups, or the entire population. It is a combination of sciences, skills and values that function through collective societal activities and involve programmes, services and institutions aimed at protecting and improving the health of all people.

Research. Activities designed to develop or contribute to knowledge, e.g., theories, principles, relationships, or the information on which these are based. Research may be conducted simply by observation and inference, or by using experiment, in which the researcher alters or manipulates conditions in order to observe and study the consequences of doing so.

Pedagogical glossary

Active Learning. A teaching and learning approach that "engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work".

Brainstorming: An instructional technique with several variations, that might take place within small group or with the entire class. During brainstorming all students shortly express their ideas or concepts which are relevant to a given guiding question or central term. Criticism on the ideas is absent during brainstorming and its aim is the production of a lot and divergent ideas.

Collaborative Learning. An umbrella term that covers many different methods in which students work together to solve a problem, complete a task, or create a product. Collaborative learning is founded in the concept that learning and knowledge building is social and requires active engagement from students.

Critical Thinking. The mental processes used when evaluating information that has been put forth as true. Consists of reflection, examination, and formation of judgement. Information is gathered through communication, experience, reasoning and observation. While based in values of intellect, critical thinking goes beyond subject/matter division.

Debate Technique. A verbal technique used with the purpose of involving a group in a certain theme that will be exposed. This technique consists of dividing two or more subgroups in which each one participates in the discussion of a general theme and in the construction of a "general commitment" of all.

Group Work. Deepens knowledge, develops research and problem-solving skills; develops attitudes of participation, cooperation, creativity and collaboration; develops teamwork attitudes, social skills and knowledge.

Information. Facts, ideas, concepts and data that have been recorded, analyzed, and organized in a way that facilitates interpretation and subsequent action.

Inquiry based learning. By the term inquiry-based learning we refer to the engagement of students in learning activities during which they practice several scientific inquiry skills. Students make use of these skills in order to answer to scientific questions either posed by the students themselves or by the teacher, by the handling of authentic data, either experimentally collected by themselves or given already collected. Some common inquiry skills include constructing and using models, carrying out experiments, data collection and organization, variable handling, data driven conclusion making and communicating over scientific issues.

Knowledge. A familiarity, awareness or understanding of someone or something, such as facts, information, descriptions, or skills, which is acquired through experience or education by perceiving, discovering, or learning.

Pedagogical Techniques. Essential resources that the teacher uses to enhance the pedagogical relationship between the students and the teacher in order to ensure learning. Different forms of application to achieve the objectives of a class.

Project based learning. Project based learning is an instructional model of active learning. It has several forms, during which students work in groups on the development of projects, which often refer to authentic problems or situations approaching real life conditions. Project based learning includes the phases of project initiation, project development and project presentation.

Skill. The ability to carry out a task with pre-determined results often within a given amount of time, energy, or both. Skills can often be divided into domain general and domain-specific skills.

Sources: EuroHealthNet; Mitsloan; OxfordLanguages; Sciencedirect

Indicative literature

- Liza Wallach Kloski e Nick Kloski, "Getting Started with 3D Printing"
- Carlos Relvas, "O Mundo da Impressão 3D e o Fabrico Digital"
- Sergio Gómez González, "Impresión 3D"

Competences / Learning Goals

Key Competences

STEM / Personal, social and learning to learn

Knowledge

3D printing concepts:

- ✓ 3D technical principles and workflows.
- ✓ Tools for printing 3D models.
- ✓ Hardware for 3D printing.
- ✓ Supplies and materials for 3D printing.

Knowledge - outcome assessment:

1. Understands the importance of printed 3D artifacts to address pandemic challenges.
2. Recognizes the 3D printing process.
3. Recognizes 3D printer's main features.

Skills (abilities/competences)

General: 3D basics, Imagination, creativity
Specific:

- Printing 3D models by combining process knowledge and application requirements.
- Technical usage of 3D printing hardware, supplies and software.
- Post-process knowledge of 3D printing.

Skills – outcome assessment:

1. Recognizes hardware basic features.
2. Recognizes printer's materials and supplies.
3. Recognizes post-printing processes.
4. Is able to identify the differences of multiple 3D printers.
5. Can print specific 3D objects.
6. Is able to print artifacts that improve public health.

Affective /Attitudes/Behaviour *(beliefs)*

- ✓ Using imagination for designing real tools and materials, focusing on the printing of artifacts.
- ✓ Using creativity skills on new technologies in the development process of the solution.

Affective, Attitudes and behavior - outcome assessment:

1. Believes that is important to raise awareness on how 3D printing can help the community.
2. Believes that is an important tool during a pandemic.
3. Has intention to continue extending the skills and knowledge regarding 3D printing.
4. Is aware of the democratization of 3D printing for public health.
5. Attitude towards 3D printing.
6. Believes that is important to improve one's own personal capabilities.

Learning goals and outcomes

- ✓ Uses online tools to open and print 3D models.
- ✓ Analyzes pre-designed models.
- ✓ Identifies the printers' basic features.
- ✓ Identifies the proper materials for printing different objects for different contexts of use.

Assessment methods

- ✓ Outcome assessment
    - Qualitative - project: printing a given 3D object.
    - Quantitative – questionnaire - – impact assessment in terms of students knowledge, skills, attitudes and behaviour
- ✓ Process assessment - *assessment of the teaching-learning sequence* – observation grid*:* reaching the target audience, and extent; implementation of the scenario as planned; run of the learning scenario as expected/organizational issues to be solved; duration of the teaching-learning sequence; number of people exposed; score for likeability – students ("how fun was it to do"/ how fun would be to do again/ how could it be better).

Content (relevant to learning goals & research topics)

STEM content

- Use of 3D printers.
- Printing 3D objects and using the materials / supplies.

Non-STEM content

- Brainstorming on 3D printers and materials.
- Group and public debates.

Digital learning objects

- Introduction of types of printers (*video and PowerPoint*).
- 3D printing tutorial (PowerPoint).
- Printers' basic features: the HARDWARE (*video and tutorial*).
- Printers' basic features: the MATERIALS / SUPPLIES (*infographic and tutorial*).
- Tutorial of how to handle the materials (PowerPoint tutorial).
- Introduction of the printing process (*video and tutorial*).
- 3D post-printing techniques (PowerPoint with video)
- Introduction of the post-printing process (*infographic and tutorial*).
- Questionnaire – quantitative assessment of learnings.

Digital educational resources

- Introduction of the different printing methods (video).
- Examples of printers (video).

- Pedagogical glossary for technical terms and definitions (infographic).
- Different basic objects printable in 3D (infographic).
- Models of 3D printers (video).
- Key factors and features of 3D printers (video).
- Scenarios of use for the materials (infographic).

Available resources (link):
Photodentro Repository (http://photodentro.pafse.eu)

Teaching -learning activities (lesson plan/ learning trajectory)

Principal target:
Science and ICT classes
9th grade (+/- 15 years old students)
ICT teachers integrate other colleagues in the enactment of the scenario (e.g., visual education, mathematics and English teachers), as it aims to be interdisciplinary.

Lesson 1: Introduction of types of printers

The teaching-learning script starts with a question "what is 3D printing?".

- group discussion around the question "What is 3D printing?"

Students are divided into groups and asked to share their thoughts on what 3D printing means. This activity will contribute to reveal the students' initial ideas of the topic, helping teachers understand their skills and knowledge on the subject. Also, this activity should be presented to the students as a theoretical background of the 3D printing practical applications (3D printers, printing methods and materials) and will be important for teachers to introduce the subject on what involves 3D printing and the current limitations of scientific evidence. Example: energy consumption for operation, the costs, time-consuming for mass production, piracy and counterfeiting.

- group discussion around the question "What applications may it have?"

3D printing technology, as an environmentally friendly derivative, is used increasingly in healthcare; thus it is important for the students to correlate this technology (print an object layer by layer deposition of material directly from a computer aided design) with public health and their interactive parameters. Example: 3D printing technology can be used to visualization, education, and communication (e.g., print 3D skin, drug and pharmaceutical research, bone and cartilage, etc.).

- digital educational resource: pedagogical glossary for technical terms and definitions

The proper references to scientific terms and topics are presented, such as solid state physics, chemistry, polymers, geometry, geometrical representation, photopolymerization. This will help students gain a holistic interdisciplinary approach regarding the topic.

Lesson 2: Introduction of the different printing methods

After a short conversation about the previous lesson, 3D printing methods and approaches are presented to be discussed.

- brainstorming on the question "What types of 3D printers are there?"

Students are divided into groups and asked to Google key definitions of 3D printers and the different types of hardware. Each group should gather at least two different printer models; identify them and select the main brands for sharing (e.g. the RepRap printers, a.k.a. a self-replicating 3D printer that uses lines (filaments) for printing). Then, they go to the flipchart or whiteboard and write the main keywords.

Next step is a video presentation about the 3D printing process. After, a discussion is mandatory about their previous models and brands and their recent new knowledge about the topic learned.

- digital educational resource: 3d printer introduction (video)

Introducing 3D printing by presenting a short video with several examples of printers. Students will raise awareness on printers using the proper hardware. Furthermore, will be presented several videos made using different printing methodologies.

- digital educational resource: Key factors and features of 3D printers (video)

Key factors of 3D printers will be revealed (1. PRICE-PERFORMANCE RATIO, 2. VERSATILITY, 3. RELIABILITY). The main features to be observed are evaluated (e.g. if the printers enable the use of different types of filaments (tougher filaments like Polycarbonate); if the printers work with lower / higher extruder temperatures). Simple exercises will be done, and replicated by the students, demonstrating the variables.

- debate: “How can print this 3D model? E.g., a surgical mask.”

The aim is to show different printing methods and discuss and reveal which ones can be used to print the objects shown.

<u>Lesson 3: Printers’ basic features: the HARDWARE</u>

The teaching-learning script starts with the presentation of the hardware, providing an individual hands-on approach.

- digital educational resource: models of 3D printers (video)

A video on hardware models showing major features will be shown. And after, individually, students will replicate some basic functionalities in the printer. First approach of the hardware (equipment and features).

- learning object: 3D printing tutorial (Tutorial)

After this first approach, a simple tutorial will be provided and students will autonomously and individually perform it.

- debate around the questions
  “What was the hardware presented?”
  “Are there only a few models for 3D printing?”
  “Which are the major features of the hardware?”
  “What should be the process when using the hardware?”

<u>Lesson 4: Printers’ basic features: the MATERIALS / SUPPLIES</u>

Students are introduced to the different materials / supplies when using the 3D printer.

- digital educational resource: types of materials (infographic)
- digital educational resource: scenarios of use for the materials (infographic)
- learning object: tutorial of how to handle the materials, e.g. storage and usage (step by step)
- group work (the availability of different types of materials for group work is required, as well as the equipment itself)

Students are organized in groups (1 group – 1 material) and invited to explore the hardware and the supplies. After, they will present their findings to the colleagues. Beforehand, teachers will be made aware of the materials / supplies provided, in order to prepare the educational activities, including ceramic, metallic, polymers and their combinations in form of hybrid, composites or functionally graded materials.

Lesson 5: Introduction of the printing process

- learning objects on 3D printing tutorial (video and tutorial)

Students have an overview about the printing of simple objects by watching a video. Then, by doing a step-by-step tutorial will experiment to print a given objects previously modelled.

- group work (the availability of laptops for group work is required, as well as the printer itself)

Students are organized in groups (1 group – 1 Object) and invited to perform the printing of a simple daily object. After, they will present their work to the colleagues.

Lesson 6: Introduction of the post-printing process

- digital educational resource: finishing of the printed objects (infographic)

Depending on the technology and the materials used for printing, the printed artifacts may require post-process handling. Examples of such situations are: rinsing to remove any uncured resin from the printed artifact's surface, post-curing to stabilize mechanical properties, manual work to remove support structures, cleaning with compressed air to remove excess powder. Some of these processes can be automated with accessories.

- learning objects on 3D post-printing techniques (video and tutorial)

Students have an overview about the post-printing techniques for the finishes of the printed artifacts by watching a video. Then, by doing a step-by-step tutorial will experiment to "clean" and give the finishes to the given objects previously printed.

- group work

Students are organized in groups (1 group – 1 Object) and invited to perform the finishes on the printed objects. After, they will present their work to the colleagues.

Lesson 7-forward:

After building and presenting the printing process map, students are challenged to print other 3D object in groupwork. This is the **School Project** described down.

Supplementary learning resources and educational activities

Lesson 8, devoted to the preparation of the school project, includes:

1. Teleconference with STEM professionals (e.g., Engineers, Designers Medical Doctors, or researchers of PAFSE consortium):
Students make questions to experts with a particular focus on: a) future academic choices and career paths; b) identifying new professions in new fields of industry 4.0.

2. Visit to FABLAB:
Students make questions to experts with a particular focus on tools and materials to create 3D scenarios. These activities are relevant for students' connections with possible STEM curriculums and careers. Students are shown the working environment and dynamic of a FABLAB.

School Research Project

Topics

- Importance of 3D printing
- Technical features and principles of 3D printing
- Possible applications of 3D printing in public health

Research management, design and administration

Challenge: To print a 3D object to address communicable diseases challenges

Method: Lesson 8 to 11 will be dedicated to the school research project. Students are organized in groups; each group addresses 1 object based on the daily pandemic challenges lived. The project challenges each group of students to: 1) identify and represent their progress in the form of essay responses and using Likert scales to show their improvement from the first lesson to the last; 2) print and present an object with what they have learned throughout the teaching-learning sequences and the ideas that emerged during the teleconference with experts. A competition and reward for the best 3D objects will take place.

Teaching-learning process milestones:

1. Students will be able to propose solutions for 3D printing basic objects (masks, ventilators…).
2. Students will be able to communicate the findings, motivations and limitations of various 3D elements and shapes considered in the work process.
3. Students will be able to identify and communicate the importance of 3D modelling to address pandemic challenges but also the role Innovation.
4. Students will be able to use technical argumentation to justify policy choices.

Teaching-learning process for school project (summary):

1. Development of materials (videos, tutorials, pictures).
2. 3D printing objects.
3. Presentation of the physical 3D objects in open schooling event.

Organization of the open schooling event:

1. Each project output (physical 3D object) is presented by the students in a community setting (e.g., exposition center, municipality, garden, museum, science fair).
2. Students will prepare a pitch on how 3D printing can address pandemic challenges. Technical speeches to motivate peers to new technologies and environments.
3. Students, parents, school community and relevant local stakeholders attend the event and are introduced on the topic on how 3D printing can be used to address pandemic challenges. Furthermore, has a multidisciplinary approach, such as in art, design, engineering and mathematics.

Data Analysis and Reporting

Content Analysis.
Presentation formats.
Report writing.
Development of presentation.

Target Audience for Recommendations

School community and local stakeholders: students, parents, municipalities, designers, engineers, and local enterprises.

Public Debate and Recommendations (based on research results)
Presentation of the 3D printing produced by students in a community setting and dissemination of evidence recommendations via social, community and conventional media.

Main partner responsible: INESC TEC

Assessment Questionnaire- Knowledge, Skills, Beliefs, attitudes and behavior

Scenario topic: 3D PRINTING"

Knowledge	
1. Understands the importance of printed 3D artifacts to address pandemic challenges	**Question 1.1**: 3D printing can help accelerate the prototyping process of which artifacts? A) Personal protective equipment. B) Ventilatory support, diagnostic and consumable products. C) All of the above. **Question 1.2:** Which of the following sentences is NOT true? A) 3D printing and distributed manufacturing represent a paradigm shift in the health system. B) 3D printing is able to provide a production model that has a fast response to stock needs, being able to adapt almost in real time. C) All of the above. **Question 1.3**: Which of the following sentences represent an advantage of 3D printing in public health? A) 3D printing reduces efficiency and accuracy. B) 3D printing helps to quickly create medical equipment prototypes. C) 3D printing only reduces costs. **Question 1.4**: Which of the following sentences is NOT true? A) 3D printer machines fabricated numerous medical kits and accessories during the COVID-19 pandemic, from face shields, specimen collectors, personalized face masks, ventilators, protective eyewear, personal protection equipment (PPE). B) During the pandemic, medical artifacts were fabricated in a short period of time, as requirements and shortage of materials were increasing expressively. C) The cooperation of 3D printing knowledge with the worldwide healthcare community will not develop innovative and essential prospects in the future.
2. Recognizes the 3D printing process.	**Question 2.1:** Which of the following sentences is NOT true? A) 3D printing can take only a few days from design to final production over hundreds from a traditional process. B) 3D printing cannot create detailed objects and takes days to finish an object. C) None of the above. **Question 2.2**: Which of the following printing processes is the most common in the market for home use? A) Additive manufacturing. B) Extrusive manufacturing. C) Sheet lamination manufacturing.

3. Recognizes 3D printer's main features.	**Question 3.1**: Which of the following sentences are NOT true? A) The role of 3D printing provides custom-made adaptation of equipment's specifications. B) 3D printing helps design custom-made solutions that would otherwise be very expensive to prototype. C) All of the above.
SKILLS	
1. Recognizes hardware basic features.	**Question 1.1:** The printing platform moves in which axis? A) X. B) Y. C) Z. **Question 1.2:** The printing head moves in which axis? A) X and Y. B) Y and Z. C) X, Y and Z. **Question 1.3:** How are the printed layers organized? A) The layers are printed on top of each other. B) The layers are printed side by side. C) There is no orientation during the process. **Question 1.4:** The prices of the 3D printers vary according to which factors? A) Material and model complexity. B) Labor intensity. C) All of the above. **Question 1.5:** What is the advantage of a 3D material extrusion system printer? A) Extended use and filament's low cost. B) Limited to metals. C) Limited printing size. **Question 1.6:** What is the most common type of 3D printing technique? A) Sheet lamination. B) Material extrusion. C) Binder jetting.
2. Recognizes printer's materials and supplies.	**Question 2.1:** During printing, the supplies go through what process? A) Heated and melted. B) Heated and pressurized. C) Frozen. **Question 2.2:** In a 3D printer, what is the material that is heated and melted in the printing head?

	A) Filament. B) Metal. C) Dust. **Question 2.3:** Which of the following sentences is NOT true? A) The type of filament used in the printing process can highly impact the final object quality. B) There are multiple colors of filament available in the market. C) The filament can be melted over and over again to print multiple artifacts. **Question 2.4:** Which of the following filaments are the most commonly used in 3D printing? A) PLA and ABS. B) Wood and stone. C) Ceramic and metallic.
3. Recognizes post-printing processes.	**Question 3.1**: Which of the following sentences is NOT true? A) The printed artifact is perfect at the end of the printing session, not needing further work. B) The printed artifact needs to be sanded or polished afterwards. C) The printed artifact can be drilled or milled afterwards.
4. Is able to identify the differences of multiple 3D printers.	**Question 4.1:** I feel able to identify the differences in the distinctive 3D printers available on the market. 1) strongly disagree… 5) strongly agree. **Question 4.2:** I feel able to work with / use different 3D printers. 1) strongly disagree… 5) strongly agree **Question 4.3:** I feel able to identify the main limitations, as well as advantages of each distinctive printer. 1) strongly disagree… 5) strongly agree. **Question 4.4:** What are the two most common types of 3D Printers for plastics parts? A) Stereolithography (SLA) and Selective laser sintering (SLS). B) Selective laser sintering (SLS) and Fused deposition modeling (FDM). C) Stereolithography (SLA) and Fused deposition modeling (FDM). **Question 4.5:** Which of the following is NOT the goal of fused deposition modeling (FDM) printers? A) Simple prototyping. B) Basic proof-of-concept models. C) End-use parts.
5. Can print specific 3D objects.	**Question 5.1:** I feel able to print a 3D object from scratch. 1) definitely true... 5) definitively false. **Question 5.2:** I feel able to choose the right type of filament to print. 1) definitely true... 5) definitively false. **Question 5.3:** I feel able to print low detailed artifacts, as well as more complex ones. 1) definitely true... 5) definitively false.

	Question 5.4: Which of the following is the right format used by computer aided design systems for 3D printable parts? A) STL File. B) AI file. C) SVG file. **Question 5.5:** How much does the resolution of the pintable file impact the quality of the 3D printed parts? A) Is a minor detail with low impact. B) If the file resolution is too high the triangle may overlap and if it is too low the model will have gaps. C) None of the above.
6. Is able to print artifacts that improve public health.	**Question 6.1:** I feel able to print daily artifacts that are useful for the community's quality of life. 1) strongly disagree… 5) strongly agree. **Question 6.2:** I feel able to print artifacts for my school to help ensure better teaching methodologies and dynamics. 1) strongly disagree… 5) strongly agree. **Question 6.3:** Which of the following artifacts can be printed using stereolithography? A) Face shields and protective eyewear. B) Specimen collectors and ventilators. C) All of the above.
Beliefs, attitudes and behavior	Include: There are no correct or incorrect answers; we are only interested in knowing your perspective.
1. Believes that is important to raise awareness on how 3D printing can help the community.	**Question 1.1:** The printing of 3D objects of my own can contribute to the global society's awareness about the importance of 3D printing. 1) Extremely unlikely... 5) Extremely likely. **Question 1.2:** I am able to explain to my family and friends the importance of 3D printing. 1) strongly disagree… 5) strongly agree. **Question 1.3:** I think society still does not fully understand the importance of 3D printing. 1) strongly disagree… 5) strongly agree. **Question 1.4:** I feel 3D printing has great potential for changing the mindsets of the communities regarding the importance of a rapid prototyping process of artifacts. 1) strongly disagree… 5) strongly agree.

	Question 1.5: I believe that 3D printing is important / useful in our daily lives. 1) strongly disagree… 5) strongly agree **Question 1.6:** I understand that 3D printing technology allows a rapid progress from design to production. 1) strongly disagree… 5) strongly agree. **Question 1.7:** I feel that the free use and dynamization of a 3D printing equipment in my community can be extremely important. 1) strongly disagree… 5) strongly agree. **Question 1.8:** I feel that 3D printing can be a valuable tool for under-developed countries, where they lack basic day-to-day objects. 1) strongly disagree… 5) strongly agree. **Question 1.9:** I feel that 3D printing can be a valuable tool for countries going through a post-war situation. 1) strongly disagree… 5) strongly agree.
2. Believes that is an important tool during a pandemic.	**Question 2.1:** 3D printing is a critical tool for managing the shortage of personal protective equipment (PPE), ventilators, and other medical equipment in the communities. 1) strongly disagree… 5) strongly agree. **Question 2.2:** I feel that everyone can play a part in the creation of 3D objects to help address the shortage of materials in the community, as students, professors, hobbyists, inventors, designers, and engineers scattered across the globe can initiate their own 3D printing projects. 1) strongly disagree… 5) strongly agree. **Question 2.3:** I believe that community fabrication labs ("Fab Labs"), that use supported materials and processes, can help increase the creation of health and medical artifacts in a secured environment and decrease inequalities of access to such equipment. 1) strongly disagree… 5) strongly agree. **Question 2.3:** I believe 3D printing technology has influenced the healthcare and medical sector during the COVID-19 pandemic. 1) strongly disagree… 5) strongly agree.
3. Has intention to continue extending the skills and knowledge regarding 3D printing	**Question 3.1:** I feel that the 3D printing process is pleasant and exciting. 1) strongly disagree… 5) strongly agree. **Question 3.2:** I feel that the 3D printing equipment is easy to use. 1) strongly disagree… 5) strongly agree. **Question 3.3:** I feel highly motivated to pursue a career in 3D printing.

	1) strongly disagree… 5) strongly agree. **Question 3.4:** I feel curiosity to know more about 3D printing and improve my skills. 1) Extremely unlikely... 5) Extremely likely.
4. Is aware of the democratization of 3D printing for public health.	**Question 4.1:** I feel that the massification of printed 3D objects is beneficial for society. 1) strongly disagree… 5) strongly agree. **Question 4.2:** I feel highly motivated to start contributing with my own printed 3D objects. 1) Extremely unlikely... 5) Extremely likely. **Question 4.3:** I agree with the massification of printed 3D objects, as it can prevent an imminent collapse of medical supply chains across global economies. 1) strongly disagree… 5) strongly agree. **Question 4.4:** I understand that 3D printing technology provides an opportunity to escape the cycle of traditional production and accelerate the response to public health emergencies. 1) strongly disagree… 5) strongly agree. **Question 4.5:** I feel that the 3D printer can be, in the future, considered a common household appliance to meet our needs. 1) Extremely unlikely... 5) Extremely likely.
5. Attitude towards 3D printing.	**Question 5.1:** For me, the process of 3D printing is: pleasant :_____:_____:_____:_____:_____: unpleasant good :_____:_____:_____:_____:_____: bad worthless :_____:_____:_____:_____:_____: valuable enjoyable :_____:_____:_____:_____:_____: unenjoyable
6. Believes that is important to improve one's own personal capabilities.	**Question 6.1:** I feel 3D printing helps me expand my knowledge of art. 1) strongly disagree… 5) strongly agree. **Question 6.2:** I feel 3D printing helps me to develop my creativity. 1) strongly disagree… 5) strongly agree. **Question 6.3:** I feel 3D printing helps me lose my fear of making mistakes. 1) strongly disagree… 5) strongly agree.

Partnerships for Science Education

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006468.