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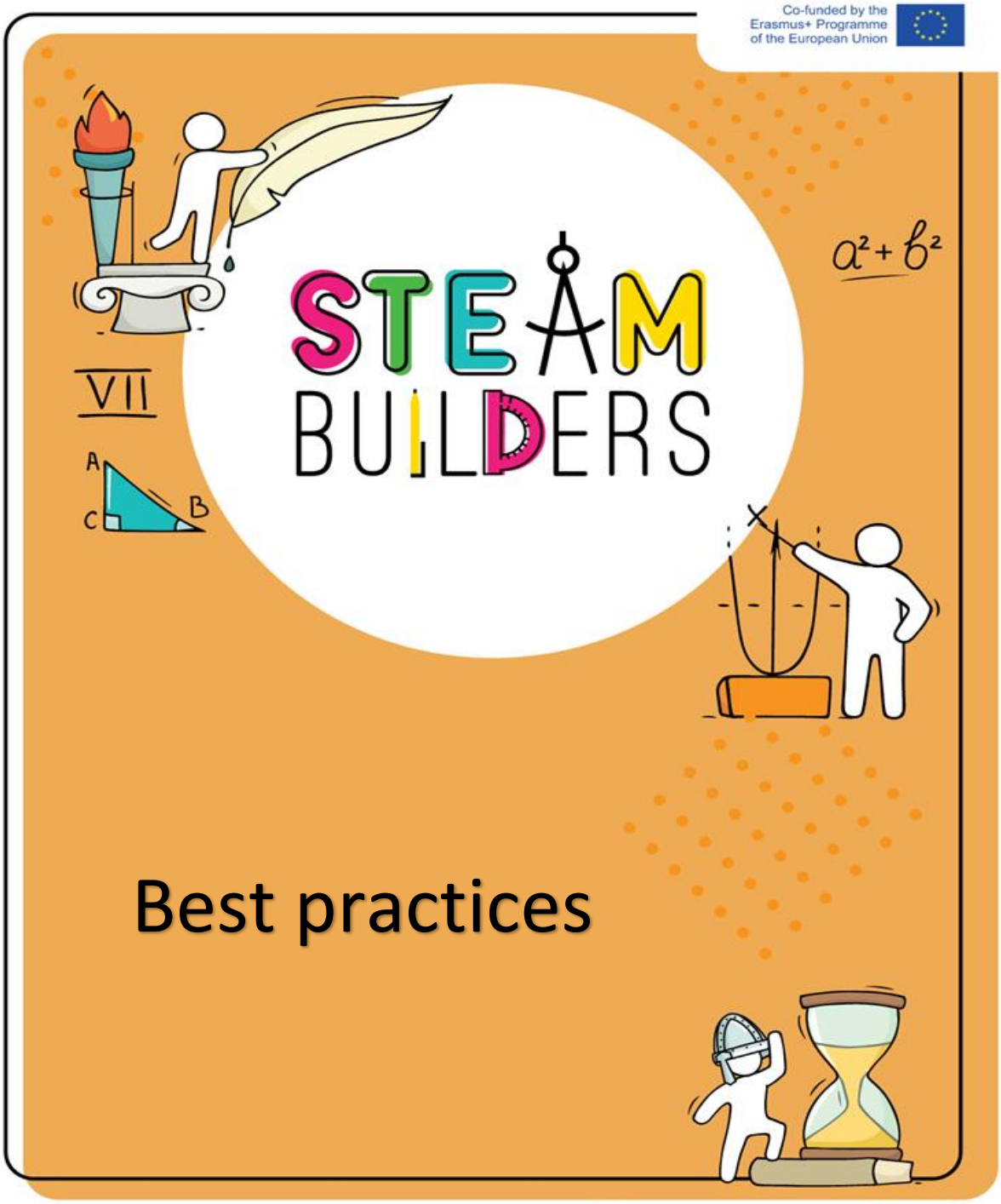


# Best practices

*The #steambuilders project has been funded with support from the European Commission. Its content and material reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.*

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*Figure 1: Photo 5th High School of Agrinio, Greece Showing a "Kilonion"*

# 1: An Introduction to “Best Practices” in STEAM Builders

The expression “Best Practice” is a set of behaviours, reflections and methods considered indispensable by most professionals in the sector. They are generally listed in "best practice” guides, in a quality approach, for ethical, hygiene or security reasons.

By the end of the 1990s, the expression “best/good practice” increased in books and research papers. The frequency of occurrence of this term increases until the mid-2000s, and then this figure stabilizes. Since then, companies, public organizations and associations have taken up the concept of “Best Practice” with the objective of improving their performance.

There are many areas where “Best Practices” are applied: health, education, development aid, food security, environmental protection etc.  Organizations use the method of “Best Practices” as a working tool in the fields of knowledge management, total quality management, and internal or external benchmarking. Internally, organizations then put in place measures to mobilize, codify, and transmit knowledge and then develop strategies for the transmission of knowledge between departments.

Some of these actions involve individual feedback aimed at codifying practices and transforming them into procedures. Other organizations implement actions aimed at making explicit the knowledge that is not formulated to go further than simple formatted feedback.

A Best Practice guide in education is generally requested by decision-makers. They need to be accountable for the resources used to provide the most effective education services. It is indeed logical that they check if the resources made available are used in the most efficient way.

Setting up “Best Practices” in the field of education can be challenging as this field is less rigid. Indeed, if in sectors such as physics, chemistry, or biology, one can attribute a scientific character (even immutable, wrongly), the field of education is considered as less normative.

**Best practice - recommendations**

What is the best way to teach students to count? What is the best arrangement in a classroom? How can tablets or computers be integrated into a science class? These are an example of questions that the “Best Practice” tries to answer. However, if these “Best Practices” are aimed at maximizing student learning and facilitating the work of the educators, it is questionable whether they can be applied to everyone and to every situation. In fact, the concept of “Best Practices” in education raises questions about the vision and conceptualization of education. After having raised standards in the results with exams and diplomas, another standard is set up: the method of teaching.

The difficulty in establishing “Best Practices” lies in the fact that different contexts, whether socio-economic, cultural, or territorial, must be taken into account. There is also the fact that each student is unique. The goal while working on “Best Practices” in education is to establish basic principles and solid methods to be as inclusive as possible.

As the concept in best practice is indeed complex and subject to interpretation, this consortium wanted to clarify these terms in the context of this project. This best practice booklet is not meant as a compendium of literal instructions on how to use the resources, but more as an insight into the tips and advice gathered from education professionals who implemented the tools and drew conclusions from them.

Of course, the implementation of the tools may lead to various results depending on the individual needs and levels of the end users, as would be the case with any pedagogical materials. Therefore, we would advise this reader to go through the best practice booklet with a mind open to suggestions but still aware of their own situation, needs and specificities.

## 2: Brief introduction to STEAM Builders

**Project background – define the needs of STEAM Builders**

2018 PISA studies have shown that 1 out of 5 youngsters in Europe is underachieving in STEM (1 out of 4 in all OECD countries) and thus is not equipped with the basic skills necessary for valuable jobs, indicating a need for alternative solutions and support systems in education. Research has revealed that a rise in underachievement in STEM generally occurs in secondary schools when we go from contextualized mathematics to abstract mathematics. The lack of contextualization of the theory is thus a major factor. The students seem unable to link what they learn in their lessons with a concrete life situation.

**Genesis of the project – How did it all start?**

Taking the above into consideration, we endeavored to find a way to root abstract STEM theory into concrete life situations and this is how we came to design STEAM Builders. The idea is to introduce pupils to STEAM (Science, Technology, Engineering, Art, and Mathematics) through the recreation of historical techniques with the help of makerspaces' technology for materials. The approach is hands-on, inclusive, and has

the benefit of promoting History and Cultural Heritage, while also interesting pupils in current school materials.

**Objectives – The goals of STEAM Builders**

The objective is to provide teachers, educators, and education professionals with the tools, pedagogy, and necessary theory to implement this innovative, cross-curricular approach to STEAM, with the aim of increasing the levels of achievement and interest in Science, Technology, Engineering, and Mathematics (STEM) of pupils aged 10 to 15.

**Outputs – Zoom in on the tools and method we created**

At the end of the project, teachers and education professionals will have full access to:

- A Pedagogical guide on STEAM through History
- A booklet on formal and non-formal approach to STEAM
- 35 manipulations and their Blueprints
- The corresponding pedagogical sequences
- A Good practices and implementation booklet

**Partners – A collective effort, the creators of STEAM Builders**

7 different European organizations from 7 countries: France, Cyprus, Spain, Belgium, Denmark, Slovenia, and Greece have collaborated for two years to develop STEAM Builders.

# 3: Methods used in the project

Before introducing a new curriculum or teaching method, it would be best to cover multiple activities that allow you to evaluate the different aspects of your project ahead of time. Pilot tests help you improve your educational content structure and discover the best ways for achieving your learning objectives.

Before implementing a new curriculum, small-scale educational research can determine what key stakeholders think about it. Organizing a pilot test in a classroom environment, trying out innovative techniques, and even conducting an assessment to receive targeted feedback from educators and students can improve the educational content structure and unfold the best ways to achieve the learning objectives.

For this reason, STEAM Builders' pilot experiments involved three key areas — project simulation, observation, and analysis. First, partners from 6 European countries recreated the blueprints in their classrooms, which gave a more hands-on approach to STEAM.  More than 600 students in total experimented and played with historical techniques and heritage, showing them how STEAM is present in every aspect of life, and has been so, since the dawn of civilization. During the pilot, educators and students identified and refined the link between STEM and cultural heritage, recreating historical monuments from their country.

STEAM Builders' pilot studies aimed to transfer knowledge on the initiative's implementation and get feedback from students and educators on the project's material acceptability, content, and educational objectives.

After analysis of the feedback received, it seems that students' responses have highlighted the importance of hands-on practical activities through the manipulation

of Blueprints, underlining how independent they felt whilst being called to discover the connection between cultural heritage and STEAM topics on their own. Furthermore, they valued how teachers became involved in their work not only intellectually, but also socially and emotionally, helping them and supporting them through the entire process.

A significant suggestion, mainly discussed by educators, was the addition of a brief introductory session to the cultural monuments that students would later exploit, in order to familiarize themselves with the topic before proceeding with the practical approach. Educators displayed a particular interest in technological approaches to historical monuments, like 3D Modelling, mentioning that it is an innovative and exciting approach to traditionally theoretical and historical topics. However, in some cases (such as the blueprint “Choirokoitia”), the timeframe of a single school period was tight, and students who had not used 3D Modelling software before did not have adequate time to resolve potential issues that came up.

## 4: The school in the museum and the museum in the school

### STEAM teaching at the Museum - from the teacher's point of view

As an educator, there can be great benefits in working to move parts of the lesson out of the classroom and into a museum. Museums can be an important player in the future of education! this is called “Udeskole”, in Danish, when goal-directed teaching is moved outside the daily classroom, it is in this shift that a small disruption of the daily bad routines and patterns of a class occurs. Pupils, and sometimes teachers, are put on the outside, one is 'away from home' so to speak, and often this happens in an environment that may be architecturally different from what one is used to. These may be historical environments such as reconstructions, open-air museums or

museums that have a particular architecture that challenges pupils with a special aesthetic which motivates pupils. It is worth noting that outdoor education is categorized as taking place in "external learning spaces", which in addition to those mentioned above can be zoos, sports clubs, etc.

*Figure 1. Students from Ranum Efterskole College doing experiments with a lithosphone - the audio in stones*
*Photo: Stone Age Center, Denmark*

What does target-based teaching do to students outside the daily classroom? In the previous publication "Non formal education in STEAM - - Booklet" we described the benefits for moving teaching out of the classroom and including STEAM-related teaching with the following arguments:

- Physical health arguments

- The link between physical activity and learning

- Learning in Context

- Social angles

- Versatile learning

- Neuro-education

It is in this environment that the daily classroom hierarchy is put on hold for a while, as pupils engage in teaching that differs from more familiar types of classroom

teaching, and which often has the character of mastery exercises, i.e., pupils learn to master small crafts through role play or other activities.

In other words, history, heritage, and art is made very concrete and alive - brought to life! This helps to tie in pupils' learning through emotions, and deeper recognition and retention of information occurs.

**How to get started?**

There are significant differences in how museum education is carried out across Europe. Some museums do not offer school courses at all, or the teaching is carried out by staff without a teaching background. Other museums have special education departments with education staff who develop, deliver, and implement dedicated educational programs and materials for kindergartens, schools, and secondary education.

There is thus a huge variety of possibilities, but also limitations. This should not prevent you, as an educator, from contacting museums to explore possibilities for collaboration. It may seem utopian to collaborate with museums on teaching, but it is already happening in several museums around Europe! Remember, schoolchildren equal higher visitor numbers for museums!

**Recommendations for starting cooperation**

- You need to be motivated to move your teaching out of the classroom - great experiences and insights await your students, and you!
- It can be a good idea to start locally! Is there a museum near your school?
- Check the museum's website to see if they offer classes

- Contact the educator at the museum by email or phone and perhaps explore the possibility of a physical meeting - collaboration is just so much easier when you know each other.
- It is important that you are well prepared BEFORE you contact the museums, especially if new classes or educational themes are going to be developed.
- Prepare all logistics well in advance: buss booking, parent slips for authorizing the field trip to a museum
- Maybe coordinate the field trip with other classes, if they are going to the museum the same day as well to lower the costs
- What do you wish? What are the learning objectives you need to achieve? What are the finances – does it cost money? Clarify expectations with each other

**The museum as a teacher – recommendations to the educational staff at museums**

Many museums have a long tradition of offering programs for kindergartens, primary school classes and secondary school students. Often these are linked to permanent or temporary museum exhibitions. Sometimes museums are used as social events, entertainment, etc. However, museums can play a much more proactive role in education, by being clear about what they can offer and perhaps also being innovative in complementing what is taught in institutions.

**Strategic questions:**

- Will or can the local municipality support cooperation between museums and schools so that the educational programs can be made free of charge?

- Who should you contact in schools to get teachers involved? It is not always a good idea to go to teachers first. Conversely, it can also be difficult to reach the leaders.
- Can you get speaking time at a leaders' or teachers' meeting to present your teaching offer? It may even be very important to meet physically.
- Adapt your teaching offer to fit the national curriculum - if you don't know them, ask teachers for help.
- Be clear in your teaching offers about what you offer in terms of the national curriculum. Keep objectives, content, time, and price in mind

**Note!** Prejudices, expectations, and lack of knowledge of each other's worlds can sometimes act as a brake on teachers using the museum as a classroom. Therefore, it may be a good idea to make visible everything that you can do beyond what is expected, e.g. Can you learn math or food science in an art museum?

**Content:**

Remember that your museum should not be a school, there is no need for that, but rather offer everything that teachers/schools have difficulty with or cannot teach!

Be aware of the aims and objectives of the different subjects so that you can adapt your aims. In this way, you are helping to solve a problem for teachers.

Focus on what you can offer in terms of local knowledge to help meet national targets, e.g.:

i) Meeting applied science such as subject terms, carbon 13 and 14, half-life, DNA etc.

ii) Making something abstract concrete...

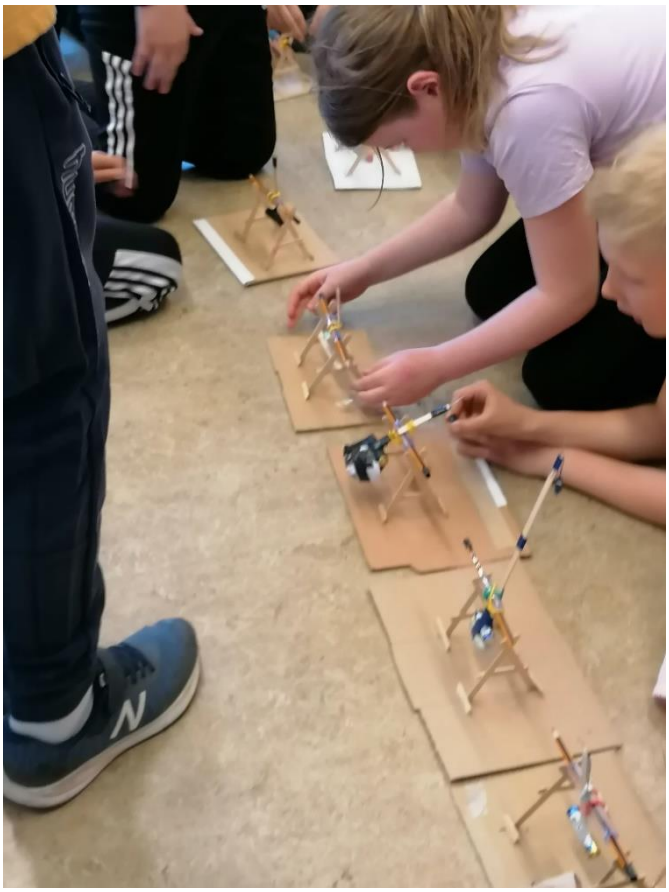


*Figure 3. Building of the medieval trebuchet in the 4th grade. Photo: Kim Callesen, Vesthimmerlands Museum, Denmark*

iii) Meeting living scientists: Historians, archaeologists, conservators, etc.

iv) Getting close to real objects, artefacts, etc.

v) Learning through shared experiences

vi) Using history/art actively

vii) For open-air museums, be aware of the transformative learning processes

viii) Museums can often offer special learning spaces for children with special needs.

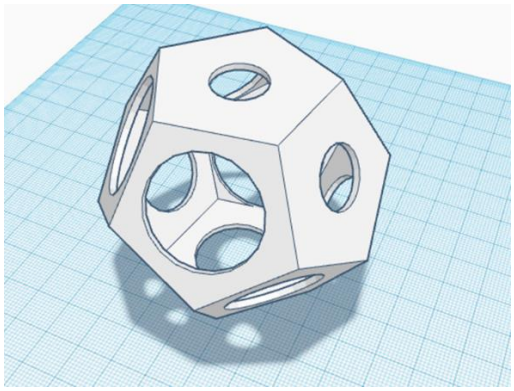
There is thus great potential pedagogically, methodologically, and didactically for schools and museums to work together in STEAM-related areas.

# 5: How do I get started with 3D printing?

## Introduction

The concept of "3D printing" is in itself a very general idea. The media, especially mainstream marketing, presents 3D printing as a magical technology of the future capable of replicating complex objects quickly. But that makes it difficult to determine what exactly 3D printing is. In reality, there are many different 3D printing technologies, but fused deposition modeling (FDM), which is the focus of this section, is the most common.

FDM prints parts using thermoplastic filament, which is basically a bead of material that can be melted, selectively deposited in layers, and cooled. Parts are built by adding layers on top of each other with specific coordinates that come from a digital model.



This technology was created because people wanted a way to rapidly prototype parts without having to wait for industrial machining. Today, rapid prototyping is one of the most significant advantages of FDM and 3D printing. 3D printing is slowly becoming a powerful manufacturing solution.

3D printing is a process, and one that does not have a quick turnaround. The process is not about knowing how to use the machine simply mechanically but instead starts

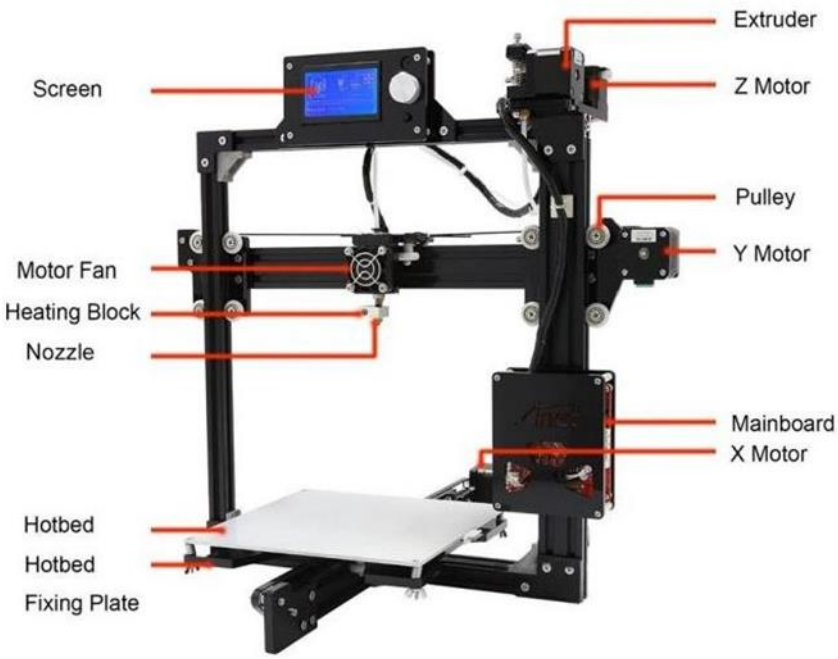
with ideation and 2D drawing and then moves on to the computer, using 3D computer-aided design software (CAD software). We have not yet arrived at the 3D printing machine itself. Once we have the 3D design, we download the file to pass it to a new software (CAM software) to be able to interpret the part that will be created by the 3D printer. This software generates a *.gcode file that is passed to the printer so that it can then reproduce the object.

The process of 3D printing is thus made up of two parts: hardware and software.

**Hardware**

The easiest way to understand how 3D printing works is to first understand the physical parts that make up the machine. It is worth mentioning that most 3D printers use three axes: X, Y and Z. The X and Y axes are responsible for left, right, forward, and backward movement, while the Z axis is responsible for vertical movement.

The most important parts of a 3D printer:



**Build platform**: The build platform (also called the print bed) is essentially the surface on which the parts are fabricated. These can be hot or cold to accommodate different materials.

**Extruder:** The extruder is the component responsible for pulling and pushing the filament through the print head. Depending on the configuration of the extruder (direct or Bowden), the extruder and the printhead are sometimes considered the same thing.

From this perspective, the extruder consists of two sub-components:

- **The cold** end is the mechanical part consisting of a motor, drive gears and other small components that push and pull the filament.
- **The hot** end contains a heater and nozzle, where the former heats the filament so that it can be extruded by the latter.

**Printhead(s)**: There may be one or more printheads in a printer, although most printers have only one.

**Control interface**: Some modern 3D printers have a touch screen that is used to control the 3D printer. On older printers, there may be a simple LCD screen with a physical scroll and click wheel instead of a touch interface. Depending on the model, there may also be an SD card slot and a USB port.

To start with the hardware, we need:

- A 3D printer (there is a universe of printers, choosing one always depends on your technological skills and your budget).
- FDM filament (another universe of colors and possibilities).

- Lacquer or other adhesion system so that the printed part doesn't come off the build platform.
- 3D printer maintenance tools.

**Software**

As discussed in the introduction to the chapter, 3D models or parts are created using 3D modeling software, such as CAD (computer-aided design) software. Here are some examples of popular 3D modeling software:

- Fusion 360 (free CAD for non-commercial use).
- SolidWorks (paid CAD)
- Blender (free surface and organic modeler)

However, most beginners in 3D printing do not have the necessary knowledge to use this type of software. If that's the case, don't worry, because there are other solutions.

For starters, there are simpler CAD software options, such as Tinkercad, a free access web browser-based program that almost anyone can use without prior experience. It is an online application designed by Autodesk, one of the industry's leading CAD software developers.

Once we have the finished model in the 3D design software, it must be prepared using a special type of software that translates the model into the instruction map that the machine will interpret. This is done using cutting software, the best known of which is called Slicer (many printers have their own G-code generation software). It is used to set many parameters, such as printing speed and temperature, wall thickness, fill percentage, layer height and many others.

The resulting file consists of G-code, the "language" of 3D printers and CNC machines. G-code is essentially a long list of coordinates that the 3D printer will follow to build its model. In other words, 3D printing is impossible without G-code files!

As the access to 3D printers has become universal for many people in recent years, numerous sites have been created as repositories of 3D models. These sites are where we can go to download parts that may already be designed and do not need to be recreated. Here are some of the most popular:

- Thingiverse (all free)
- MyMiniFactory (many free and some paid)
- Cults3D (free and paid)
- CGTrader (few free and most paid)
- Printables (all free)

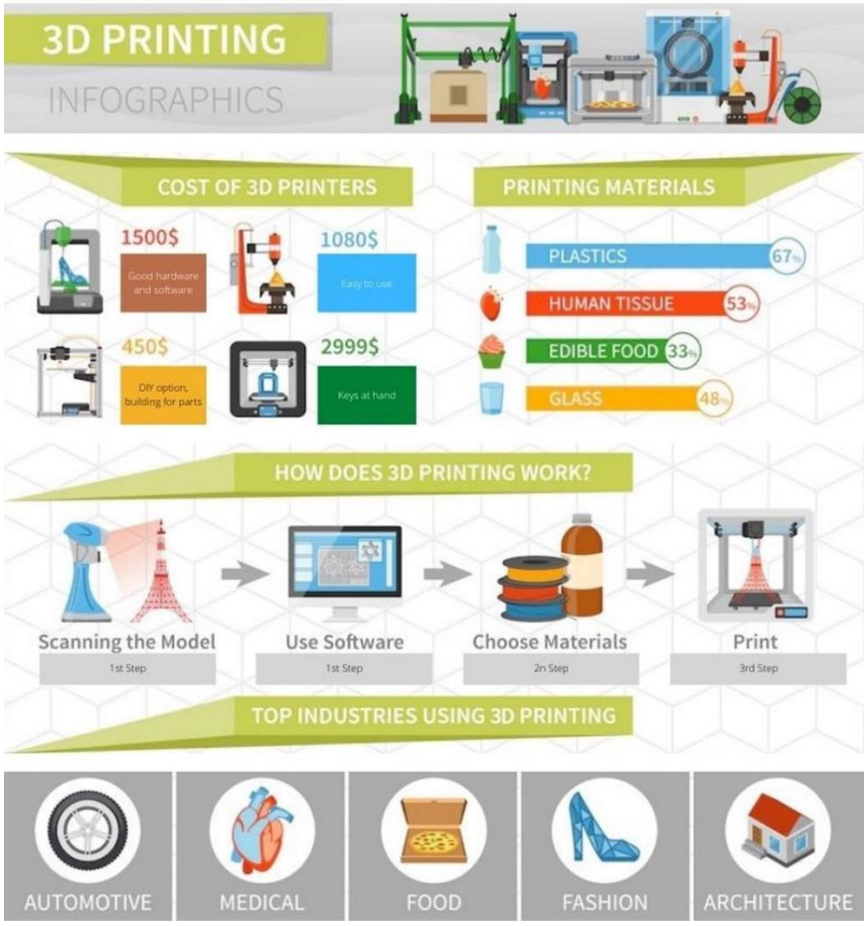
**Pedagogical recommendations or limitations**

In primary and secondary school contexts, educators are leveraging technologies and maker pedagogies to enable more inquiry-oriented, hands-on, engaging, and student-centered forms of learning (Freeman, Becker and Cummins, 2017). These efforts are in line with recent international emphasis on skills development in science, technology, engineering, arts and mathematics (STEAM) disciplines (Organization for Economic Co-operation and Development, 2018; UNESCO et al., 2015), as well as on the development of so-called 21st-century skills, such as collaboration, critical thinking, problem-solving and creativity (Broadband Commission for Sustainable Development, 2017; Luna Scott, 2015).

Understanding and applying maker technologies and pedagogies represent key challenges for school leaders and classroom teachers, many of whom have had

limited exposure to maker-based teaching and learning through professional learning opportunities to inform their own classroom practice. Furthermore, the lack of research on pedagogies that support and constrain learning and teaching in maker spaces means that teachers have little empirical guidance on which to base their practice (Papavlasopoulou et al., 2017).

One of the most important elements when including 3D printing processes in the classroom is patience. Be clear about every step of the learning process. And create a reasonable timeline for the design of the project.



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# 6: Selected cases from the project

## Case 1: Thoughts on the creative bricks - children's encounter with art through high-profile toys.

Danish multi-artist Per Kirkeby has created a series of brick building sculptures around Europe. He didn't call them sculptures, but rather "machines of light and shadow". This phrase is the inspiration for the blueprint of the same title, which is an attempt to learn geometry through local building art via experimental constructions of Stehle (a city gate based on a square ground plan) in LEGO. This was the background

for 14 test sessions over 5 days with 344 participating students aged 6 - 13 from Aars in Vesthimmerland, Denmark.

*Figure 4. A Stehle I a roundabout in Aars, Danmark Photo: https://skulpturblog.org/2020/10/06/aars-2006-byporte/*

Each course of 60 min. consisted of:

- Introduction to the Museum, Per Kirkeby and STEAM Builders Erasmus+ project
- Production of 1st model with shadow test
- Production of 2nd model with shadow test
- Evaluation

In the introduction, students were asked: "if they would like to be a kind of test pilot" for the project. All pupils indicated that they were interested, and there was even a great deal of curiosity about the project itself among the students.

Per Kirkeby had a very experimental approach to the use of bricks, so LEGO was chosen as the closest building material for the students, which excited many students who spontaneously expressed "Yes!" or " Cool ", clearly indicating the status of the toy among the students.

Afterwards, several students said, "It's cool to be given a specific task in LEGO. It's a different way of building".

A few students had limited types of bricks available. Asked if this was an obstacle to their construction, they replied: " No, it was fun that we didn't have so many kinds to choose from, because it forced us to use our imagination!"

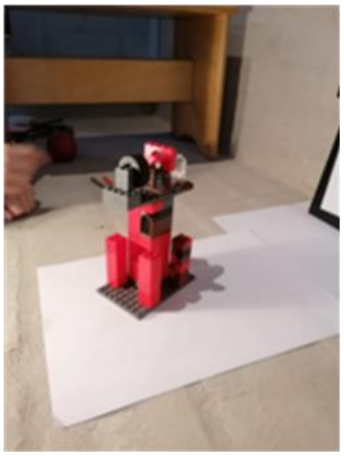

*Figure 5.. Stehle built by 6-year-old students. There was a long explanation for the mounting on top along the lines of: "when the cars lights hit, they would form shadows...." Photo: Kim Callesen, Vesthimmerland Museum*

The age of the pupils was mostly expressed in the constructions. The younger pupils were more fabulous about the function of the Stehle, where the older pupils were more concerned with the aesthetics.

**Periodic gender-segregated teaching and other types of segregated teaching**

Whether this is something special with Danish children remains to be seen, but the use of LEGO as a teaching material had equal engagement with the sexes. Perhaps it was the open solution possibilities of the task that appealed to the pupils? as LEGO is often considered to have a great appeal to boys? The girls certainly showed great commitment to the programs.

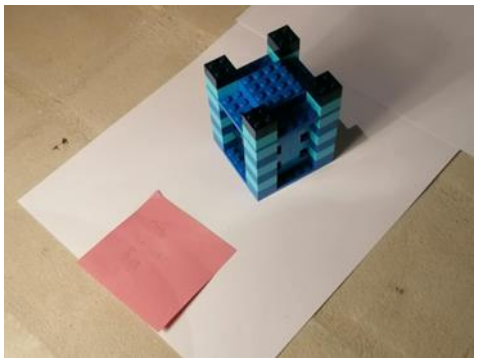

*Figure 6.. Stehle built by 12-year-old students. Note the colour coordination.*
*Photo: Kim Callesen, Vesthimmerlands Museum*

In two of the classes, the teachers had chosen to divide by gender, or rather by boy/girl. These were two very quiet and concentrated sessions, which does not lead us to recommend this. However, there may be a perspective in being aware of the possibility for shorter periods, as LEGO may have such a strong appeal to certain groups that it even leads to almost excluding pupils who are not so used to constructions with bricks, so the division may be based upon:

- Age
- Experienced/inexperienced builders
- Gender
- Assign specific blocks to specific groups of students.

Machines of Light and Shadow showed it is possible to create interdisciplinary programs, even where local art became a catalyst for math, science, and interest in the EU. The test also showed a program with great engagement and participation in the idea and building phase from both girls and boys.

## Case 2: Experiences with STEAM Builders and children with SLD

Brief intro to SLDs – SLDs in STEAM context

Small presentation of the SLDs:

A Specific Learning Disorder, or SLD, is a permanent condition that affects the learning process of an individual. There are different SLDs: Dyslexia, Dysgraphia, Dyscalculia, Dysphasia, and Dyspraxia. They have a neurobiological cause that affects the way the brain processes information: how it receives, integrates, retains, and expresses information. This can affect the cognitive development of a learning ability but does not stem from a physical impairment or intellectual disability. Each SLD generates its own set of challenges, that impact students' school life. For more information, we advise you to refer to the Pedagogical Guide of this project.

Difficulties related to STEAM learning

Most SLDs can affect STEAM learning indirectly due to the way they affect the brains ways of processing information. For example, Dyslexia can translate into difficulties in reading and language-based processing skills. It makes decoding math problems more difficult as it can affect reading fluency, decoding, reading comprehension, recall, writing, spelling, and sometimes speech.

Dyscalculia is the most obvious disorder when it comes to difficulties in STEAM as it generally translates into difficulties with understanding math symbols, counting, memorizing, and organizing numbers, thus hindering the affected person in calculus or abstract mathematical operations.

[1] PISA. (2018). *Home*. OECD iLibrary. https://www.oecd-ilibrary.org/sites/a9b5930a-en/index.html?itemId=/content/component/a9b5930a-en

SLD needs in STEAM

SLDs will benefit from more sequences, and concrete materials, that will help them visualize, interact, and understand the theory they are learning. They need clear steps and the opportunity to link things to concrete situations to integrate the materials more easily. This is addressed with the manipulations' blueprints in STEAM Builders.

Presentation of outputs tested: What and why?

- The outputs:

The main output tested were the manipulation blueprints and their accompanying pedagogical sequences. All partners have tested different ones and the results are generally very positive.

SLDs' perspectives on STEAM Builders: usefulness and challenges

- Usefulness:

The manipulations created in STEAM Builders allow the pupils to be able to interact with the class materials, visualize them, and manipulate them, which will help them retain the information better as all their senses are engaged during the session. They will also be able to understand the mechanisms fully, instead of simply learning them by heart and forgetting them as soon as the test is over. This also allows the pupils to participate in the learning process actively instead of passively. Finally, it creates interest and boosts engagement in the lesson, which is always a source of better achievement.

- Challenges

Some of these manipulations help learners understand complex theories, whilst also manipulating elements. Furthermore, although fine motor skills can be a source of challenge for students with SLD, teamwork can palliate this challenge easily. Also, such activities are limited in terms of long-term possibilities; unfortunately, a teacher will not be able to make his whole school year like this. This is a tool to be used punctually to boost interest and engagement.

Case study: testing phase

- The tests process

The testing phase was very challenging due to the time of the year it took place, however, the tests yielded very positive results for all outputs. One of our students felt very intimidated by the experiment, especially with the pulley system, but once she realized that the guidelines were simple and clear, she could do most of the steps on her own. Even though the materials may have seemed difficult to use at first, she realized that Physics was more concrete than she thought. She also said that this method should be applied to all Physics concepts to engage more actively with the subject that the teacher discusses.

- Impressions and testimonies

The teachers conducting the tests were very satisfied with the way the blueprints were constructed, especially the “compass” one, in which they had to say:

“This one was really nice because it really helped the student understand how the compass works, even though it had been explained earlier through the sequence. Indeed, this more concrete part where he had to magnetize his needle by thinking about the positive and negative sides of the magnet really pushed him to think about

the functioning of both magnets and, of course, the compass. In addition, this blueprint contains a more personal "creation" part with the compass rose to be drawn, which allows the student to quickly review some geometry notions while applying them to something concrete, but which also allows him to make more aesthetic choices (even if it is simply a matter of choosing the colors and shape of his letters). This allowed the student to feel like they were really building their own object and not just an object to learn something.

From my point of view, it is also the one I preferred to work on among the three proposed because it allowed me to work on several notions at the same time while producing a very concrete and visual result for the student. Moreover, the materials used are very basic and therefore the activity requires very little preparation beforehand, which is not negligible. The way that the explanations are supported with photographs of the construction's evolution is also very pleasant. It allows students to have a certain autonomy while increasing their feeling of building their own object and being an actor in their learning. Also, for those who have problems of confidence, to have the impression to build these objects by themselves and not to need help from the adult present."

Conclusions

Considering all the comments, the blueprints were revealed to be both very interesting from the point of view of the teacher and very engaging from the point of view of the pupils. The step-by-step explanation with pictures allows pupils to be autonomous and implicate them in the creation of a very concrete result they can keep afterward, while only requiring basic materials and little preparation in advance. Certain fine motor skills manipulations in specific blueprints can be challenging depending on the pupil realizing them. However, they are effective in their goal:

contextualizing abstract STEAM theories, helping the pupils understand the mechanisms of the concepts, and boosting engagement and achievement levels in STEAM for all pupils.

## Case 3: STEAM Builders in high school

A secondary school is an institution that provides general education and introduces students to various topics. Some secondary schools offer both lower secondary (ages 11 to 14) and upper secondary (ages 14 to 18), i.e., levels 2 and 3 of the ISCED scale, but these can also be provided in separate schools. Young people must have excellent skills in interpreting information, problem solving, and knowing how to gather and evaluate evidence to make informed decisions (Bourn, 2018). As future leaders, they will face increasingly complex problems, which is why a working knowledge of STEM is critical (Digital Skills Gap Index, 2021; Cedefop, 2015).

High school students can enroll in robust STEAM programs to broaden their worldview while learning important life skills. Some of the advantages of STEAM programs for high school students include:

- Improved problem-solving skills
- Improved collaboration and communication
- Confidence to pursue careers and college readiness
- An advantage for the future job market

But how can teachers introduce STEAM in their classrooms? STEAM Builders provides a methodology for introducing STEAM activities into high schools.

It utilizes a multilayered approach to help students build up their STEAM abilities, allowing teachers to have inclusive pedagogical sequences that can be used in their classes. Based on a consortium of partners with various expertise in STEAM education and in education in general, we aim to develop, evaluate, apply in real classes, and enhance a number of STEAM resources.

According to the STEAM Builders approach, the main steps for introducing STEAM into high schools are:

1. Development and evaluation of historical artifact blueprints by domain experts.

2. Development and evaluation by educational specialists of pedagogical sequences for each blueprint.

3. Application and evaluation of the pedagogical sequences and blueprints in educational activities to estimate the added value of these resources.

**An example**

During the school year 2021-22 the 5th Senior High School of Agrinio utilized a blueprint and a sequence developed in the project with 42 students in total. The students were 16 years old and attended a Greek Senior High School.


*Figure 7: Photo: 5th High School of Agrinio, Greece*

Three learning hours were used in total, including the creation of the sextant. The blueprint concerned the creation of the sextant, and the pedagogical sequence included the application of the sextant to measure the height of their school. By using a "learning by doing" approach, students:

- developed the sextant using the blueprint,
- learned with the help of the teacher about Thales and his theorem on similar triangles,
- studied about Xenagoras (2nd century BC) who based his research on the theorems of Thales, calculated the height of the peak of the Greek Western Olympus Mountain, named Flambouro,
- and finally, they measured the height of their school in groups by doing the necessary calculations.

*Figure 8: Photo: 5th High School of Agrinio, Greece*

All the students actively participated and enjoyed the activity. They created some objects, learned some historical facts, and realized the practical potential of mathematics in everyday life.

A short questionnaire was distributed to the students and then a discussion session was held to realize their views and beliefs. Table 1 shows the most interesting part of the questionnaire and as we can see students are quite positive towards our teaching approach.

*Table 1: Opinions of the students*

| *Question* | *1 (Strongly disagree)* | *2 (disagree)* | *3 (Neutral)* | *4 (Agree)* | *5 (Strongly agree)* |
|---|---|---|---|---|---|
| A. The content of the activity is interesting and attractive | | | | 2 | 40 |
| B. The content of the activity is clear and understandable | | | | 3 | 39 |
| C. The activity was able to keep me interested and motivated | | | | | 42 |
| D. I want more activities like this! | | | | | 42 |

The above activity is a simple paradigm of the successful integration of STEAM activities into high schools. The STEAMBuilders project provides step-by-step guidelines to support the integration of STEAM activities. Students are assisted in their exploration of various implementations and teachers are supported with specific resources.

References

Bourn, D. (2018). Understanding global skills for 21st century professions. Cham: Palgrave Macmillan, 2018.

Cedefop (2015), Skill shortages and gaps in European enterprises: Striking a balance between vocational education and training and the labour market, https://www.cedefop.europa.eu/files/3071_en.pdf

## Case 4: When schools use the local area in teaching

AT Fermat Science, we propose workshops related to the local area and heritage of Beaumont de Lomagne: the PatriMaths workshops. One of them is: **"The city in the Middle Ages".**

This workshop is intended for 6-year-old children: they discover the foundation of the royal bastide of Beaumont, created over 800 years ago on the initiative of Philip III the Bold, and the abbot of Grand Selve. The children walk through the town in the streets that intersect at right angles, traced by the surveyors of the Middle Ages, and discover, as they stroll through the heart of the town, the architectural principles that presided over its construction.

From the Cultural Centre of Beaumont de Lomagne, the children discover the timber-framed houses. The bastide of Beaumont de Lomagne is rich in these typical 16th century houses, the oldest remains of the town. Head toward the magnificent residence of the Lords of Argombat, located in rue de l'Eglise, then on to rue de la République where the remarkable house of Jean d'Armagnac is located. During this stroll through history, they discover many other aspects of science.

Back at the Cultural Centre, everyone can make a model of a town in the Middle Ages. They are provided with a laser-cut example of a timber-framed house, a technique that Camille, a mediator at Fermat Science, will assemble for them. Then, with the help of various materials, sand, gravel, cork, characters, animals and objects, their model will come to life... And they will be plunged into the heart of a medieval town!

After having discovered the life of the past as reflected in the architecture of the bastide, they can keep their work and share with their family this treasure born of their hands.


*Figure 9: Fermat Science, France*

**In the PatriMaths workshops, we propose to children aged 6 and over to create a work of art using stained glass.**

From the Cultural Center of Beaumont de Lomagne, the children set off for the 14th century Gothic church of Notre Dame de l'Assomption. The mediators draw their attention to one of the stained-glass windows on the outside façade.

From the narrow street, it is impossible to make out, so the group enters the church and there, it is a discovery! From the inside, the light reveals it, rich in colors and shapes.

The mediator then explains to children how a stained-glass window is made: the choice of the model and the making of the model are the first steps. Then, the master glassmaker represents the design, the colors, the lead links and the metal frame, all in life size. The glass is cut with a diamond, each piece is painted with paint for glass and fired. All the pieces are assembled and joined with lead. The resulting glass roof is then fixed with a metal frame.

After the visit, everyone returns to the Cultural Centre so that children can work on their own stained glass. With the help of various tools at their disposal - compasses, rulers, protractors - the children are invited to become creators in their turn. Mixing symmetry and geometry, they reproduce the model proposed by the facilitator: the church and its stained-glass window come to life. All that remains is to transfer it onto transparent paper and illuminate it in the manner of a master glass artist.

Thanks to this workshop, children have the possibility, through one's heritage, an ancestral technique, an art, and to play the artist in turn, to become a master glassmaker!

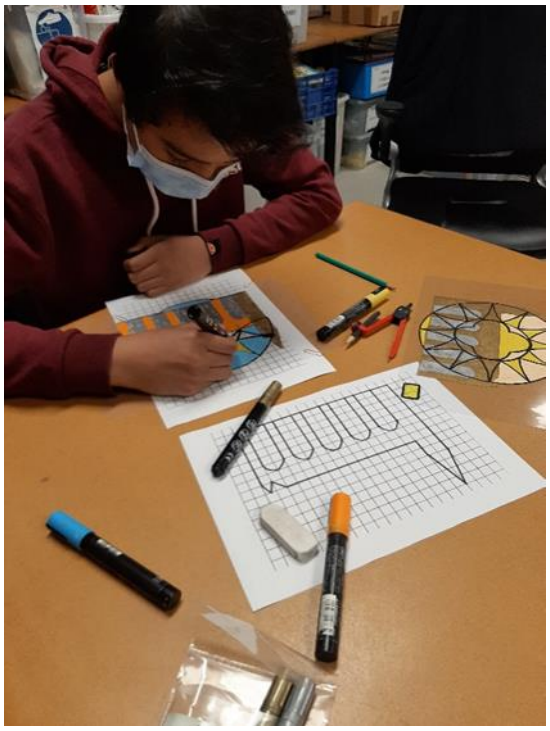

*Figure 10: Photo: Fermat Science, France*

**Children can also discover Beaumont de Lomagne from a geometric perspective with the geometric walk workshop.**

We set up a geometric walk in the town where the mathematician Pierre Fermat was born. Its function is the discovery of his town from a geometrician's point of view, thus getting the children to observe their heritage and the architecture and to look at the different architectural forms and dimensions, thinking like a mathematician.

Beaumont de Lomagne is a bastide with a strong architectural potential and a very geometrical shape like all bastides. The children must identify symbolic places charged with geometry with their guide during a visit to the town, understand the history of Beaumont de Lomagne, imagine questions to ask in relation to what they have observed, take photos of the places and the architecture, think about the tools to be used to measure the town, and draw up a visit document.

*Figure 11: Photo Fermat Science, France*

This visit is then presented to the parents, who put themselves in the shoes of visitors who discover Beaumont de Lomagne from a geometric point of view.

This allows the children to be valued by their parents, who can pass on their knowledge, but it also allows them to show their parents a different way of approaching mathematics.

The creation of this visit allows the children to immerse themselves in various disciplines (math, history, heritage, writing, creation, observation, artistic practice) and to implement numerous fields of competencies for the realization of a global project.

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## Case 5: Implementing a heritage workshop

### 1. What is a workshop?

A workshop is a meeting in which a group of people engage and interact in intensive discussion and activity on a particular subject or project. In general, workshops are short educational programs (lasting from a few school hours to several few days) that involve participants, allowing them to acquire some technical or practical skill or learn some concept open to any field of application.

The planning and preparation of the workshop is time-consuming for the mentor, as every workshop is unique. To achieve the best results, it has to be prepared with the participants and the topics in mind. On the other hand, this means the same workshop can be applied to present different topics and teaching areas.

## 2. Planning, preparation and implementation of the workshop

In the STEAM Builders project, GoINNO Institute have organized hands-on workshops with pupils aged 10-14 years to test developed materials. In this paragraph, we will describe the preparation and the implementation of the workshop based on the practical example.

### 2.1. Planning phase – define the participants (number, age), mentors, activities

Firstly, we have chosen the target group and the activities. Then the maximum number of participants has been decided - the limitations can be the time, materials, space, and number of mentors. We decided on the maximum number of 20 participants (aged 10-14) with 2 mentors. Mentors are always welcomed, preferably more rather than fewer. We recommend a minimum of 2 for the group of 10-20 pupils to be sure the activity is running smoothly and pupils receive help with hands-on work when they need it. The activities were chosen taking into consideration the target group and their interests – we recommend a maximum of 2 different hands-on activities, not too simple or too complicated. The important thing is they can do the activity almost alone, with their own hands. Pupils can do the activity also in pairs or groups, but everyone should be actively involved.

We decided to do 2 different experiments – “The watermill” and “Exploring rocks” in 3 school hours with a break between.

### 2.2. Preparation phase (materials, place, invitations, applications, etc.)

**Space**: We have to choose the place for the workshop. In our case, we selected the classroom at the public library, but it can also be a school classroom, or some other

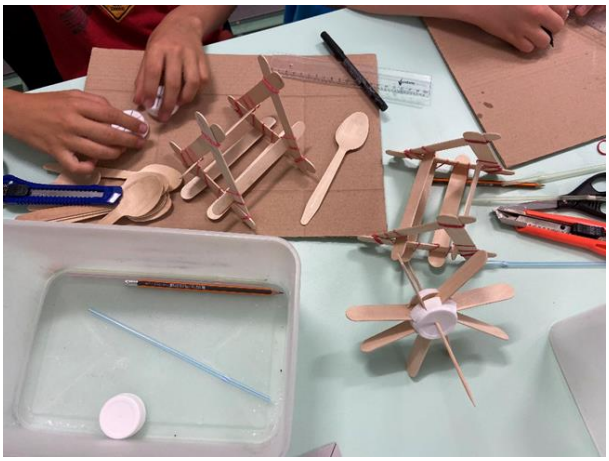
public space, (in the warmer time of the year, it may also be somewhere outside). We need a safe environment to avoid any injuries or damage and provide enough space.

**Materials:** Prepare enough materials for all the participants, as well as some extra materials just in case.

**Invitations**: Prepare the invitations and send them to the interested public – we targeted parents with schoolchildren. We shared the event details on social media pages and created an online application form, which we regularly observed. If there are more applicants than there are places in the workshop, think about making two events. Do not forget to define the key information: place, time, duration, who can apply, and a brief description of the topic.

### 2.3. Implementation

Mentors have to be at the place before the workshop starts to prepare the place accordingly and the materials needed. When it starts, divide participants into smaller groups and start with the activity. Pupils are always excited if they can take something home, that they have done themselves. Making something from easily accessible and inexpensive or even recycled materials makes the idea for the pupils to take their models home reachable.



# 7: Recommendations

The figure below gives you the 7 partners' best recommendations for getting started with STEAM-related teaching:

| Institution | Recommendation |
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| **Logopsycom** | |
| Preparation is key | To implement an activity as smoothly as possible, preparation is an essential step. To be sure that enough tools are available, and in working order, that the materials necessary for the creation of a manipulation are in stock, and that you have a bit more than is necessary. (An error is always possible, better prepare for several trials). But also, it is good to be aware of the facilities available, the space, the desks, etc., as they may be necessary for the activity. Another essential point is to realize the activity on your own beforehand, so that you may identify points of difficulty or moments of particular attention to help the students yourself and may guide them the best you can during the activity as well. We would advise you to recreate the manipulation once by yourself and to prepare all materials in plenty of reserve for the activity. Any leftovers can be used for other activities as well. We advise recycling materials as much as possible. |
| Cooperation rather than competition | A lot of the time, competition is used as a way to motivate students to succeed. While this may work on some students, not all are competitive, and the students" losing" may lose |

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| | interest once the winners are done and they may stop halfway since there is no point anymore. This also leaves a feeling of failure in their minds, which is not the objective. We would advise focusing on complementarity and cooperation in these activities. There may be different roles or different steps with" leaders" appointed in turn for each step in order to change things around, but everyone should participate in their own capabilities and be rewarded by the general success of the group. This will allow for better inclusion of students with a different set of skills than is usually required in class exercises and to value neurodiversity as well. |
| Leave space for trial and error | These manipulations are a perfect opportunity to work on their scientific curiosity and help them develop a positive outlook to try on new things. When confronted with a new problem, it is perfectly ok for students to try and fail at first. This is also part of the learning process, especially in a STEAM context. The objective is to make the students reflect and try to find a solution. It is normal is they don't succeed on the first try. This will promote out-of-the-box thinking, active participation in class (as failure is not punished) and resiliency. Students will be less likely to not try something or to abandon quickly when they don't find the answer at once. If you have the opportunity, it would also be nice to have workshops on trying to resolve a problem children may have encountered at home or in their everyday lives. |

| **Fermat Science** | |
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| Changing the environment | The arrangement of a classroom or workshop room should be flexible. Ideally, the arrangement of tables should be adapted to the proposed activity. However, changing the table arrangement can be time consuming and noisy. So, if you want to move the tables in the room when you do a STEAM workshop, it is best to teach the students how to do this. At the beginning of the year, show the students how to do this quietly and quickly. When the students are trained and used to it, it can take less than three minutes to change the configuration. |
| Don't be afraid to go out! | Getting out of the classroom facilitates authentic or experiential learning and gives better access to the main pathways to learning (Visual, Auditory and Kinaesthetic). Students not only experience sciences in concrete and novel settings but can be liberated from the sometimes-restrictive expectations of the classroom.<br>Learning science outside the classroom, such in a museum, is not just an enrichment, it is at the core of empowering an individual's understanding of the subject. |
| Take away the risk of inequality | For students who are socially distant from culture, the STEAM language can be a source of misunderstanding generating failure and stress because there is often a discrepancy between the science sense and the real sense. It is therefore essential in the non-formal learning to use the right word. To take away the risk of inequality, it is necessary to develop:<br>- Non-formal activities accessible to all and everywhere outside schools |

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| | - The training of mentors in the different methods of science education and science language |
| **GoINNO** | |
| Leave the students free way to learn – they can have fun and learn at the same time. | The mentor must be the guide but not lead all the activity in his rhythm to achieve planned results. It is essential to know, where the activity starts and what are the goals, however, the result is the consequence of the participants, their motivation, skills, and knowledge. Do not be afraid if they do something different than you expected. Also, fun is the part of the hands-on experiment, which is engaging and motivating. The goal is achieved if teacher combine that with learning. |
| Do lessons as workshops – it is intensive educational experience done in a short amount of time. | To do hands-on experiments is workshop good choice as offers to students a chance to try out new methods and potentially fail in a safe situation. Each student is surrounded by a mentor, who can help him in difficult situation, and other students, which enables a quick and efficient transfer of knowledge and feedback between mentors and students. It can create a sense of community and cooperation among students leading to greater motivation for the activity. It is important everyone should get the chance to do the at least some part of hands-on activity by himself, what will lead to greater learning achievement. |
| Mentors must be able to adjust to new conditions. | Preparation of the mentor to guide the activity should be done by the mentor in advance, however they must be prepared for different situations. Usually, the mentor must build some parts of lessons structure and plan through the implementation of the activity and not beforehand. It is essential the mentor can |

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| | see, how to give the participants as much knowledge as they can get, considering the topic and audience. |
| **CIP- Citizens in Power** | |
| STEM teachers to incorporate Arts in their curricula. | STEAM's foundations lie in inquiry, critical thinking, and process-based learning. The entire idea surrounding STEAM lessons and the STEAM approach is that it's based around questioning. We want to start asking non-Googleable questions.<br>Inquiry, curiosity, being able to find solutions to a problem, and being creative in the finding of the solutions is at the heart of this approach. This means that the humanities are woven into STEAM just like everything else. |
| Develop a makerspace in your school. | The terms STEAM and makerspace are often thrown around together. Here's why: The STEAM education movement emphasizes 21st-century skills, project-based learning, and the interconnectedness of academic subject areas. Teaching STEAM helps students become more proficient in collaboration, questioning, problem-solving, and critical thinking. How do makerspaces fit in? Makerspaces are a hands-on method for STEAM learning, giving students space to explore science, technology, engineering, arts, and mathematics. |
| Integrate math and science into projects seamlessly | Integrate math and science into projects seamlessly. The math and science that your students complete should be relevant to their current project, relate to real-world scenarios and ultimately serve a purpose. For example, perhaps math |

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| | equations will ensure that their design works properly or help them understand how to create something. |
| **Tràsit Projectes** | |
| UNESCO and Sustainable Development Goals | Heads of State and Government, senior UN officials and representatives of civil society gather in September 2015, as part of the 70th session of the UN General Assembly and have adopted the Sustainable Development Goals (SDGs). These objectives form a program of sustainable, universal and ambitious development, a program of the people, by the people and for the people, conceived with the active participation of UNESCO.<br><br>https://en.unesco.org/sustainabledevelopmentgoals |
| Inclusion | MakerEducation activities, in a well supported environment with access to tools and materials, can help young people feel connected. They can give them the opportunity to communicate their thoughts, feelings and passions through creative yet practical methods, as well as learn about the importance of social responsibility and inclusion.<br><br>http://m4inclusion.com/ |
| Don't be afraid | The "Makerspaces for Innovation in Teaching practice" focuses on the research process to develop more engaging teaching methods and real-life learning environments. The educational potential of Makerspaces and FabLabs (and the rapid prototyping technology used in these spaces) can support teachers and educators in this field. In particular, the "MakIN |

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| | Teach" project integrates the Do It Yourself (DIY) philosophy typical of these spaces with activist theory and ideas related to "learning to learn" and "active learning". |
| **5th High School of Agrinio** | |
| An early start | Despite what most people think, it's never too early to get kids interested in science and math. Recent research says that every effort should be made to get kids involved as soon as they start elementary school. Studies have shown that kids decide if they want to be scientists, engineers, or mathematicians during elementary school. |
| Diversity in STEM | There are not enough women in engineering and computer-related jobs. STEMs teacher can make a difference by encouraging women and students from underrepresented groups to go into the most in-demand and well-paying STEM fields. |
| More educational actions | More cross-disciplinary and applied research programs to help students at all levels of education develop a wider range of skills and incorporate STEM into other subjects to show how and where STEM is used in the real world. |
| **Vesthimmerland** | |
| ”Less is more” | Don't overcrowd the activity. Pupils absorb a huge amount of new sensory input and too many activities can create clutter and confusion. Simplicity leaves room for pupils' own imagination, action, ideas, and expression. When pupils are invited to be co-creators in this way, teaching becomes meaningful. |

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| Chronological sequences and whole processes | Create a balance between calm, contemplation, and momentum. The process itself should be chronological, with activities that have logical causal links. Let the pupils carry out a work process from start to finish, so that all the sub-processes in a work cycle are completed. For example, the water drawn from the well is used for something, the coffee beans that have been ground are boiled to make coffee. |
| Use simple materials | Choose simple materials and recycle e.g. round sticks, plastic bags, plastic cups, cardboard boxes, branches etc. in your teaching. This helps to keep material costs down. You may ask pupils to help collect materials to contribute to the lesson, and it can create curiosity about what the materials are/can be used for. It is an advantage to build up a "materials bank" to keep costs and preparation time down. |

# 8: Perspectives

STEM and STEAM has been around for quite some time now but teaching through STEM experiments and hands-on activities and combining it with “A” in STEAM are still perceived as something new and sometimes very challenging for teachers and other educators.

Teachers are people who dedicate their life to transferring knowledge to the next generation. Even though they teach pupils every day and have expectations on the level of knowledge of pupils, in their approach towards learning the teachers themselves are very often not confident. For this reason, they do not embark on something new, for example teaching STEM experiments and hands-on activities in school. This reflects the fact they are not familiar with this teaching methodology as in the University in most cases the pedagogical study programmes do not cover hands-on or experimental/project-based STEM teaching methodologies, or these are only briefly mentioned without any solid pointers or examples.

Another issue lies in the fact that teachers are overloaded with making sure they are covering the national curriculum and lack time to prepare and implement new STEM activities. Even when the teacher decides to incorporate STEM activities, they lack quality materials for hands-on teaching lessons to use in school classes, as there is a low number of helpful resources on how to guide such lessons. Therefore, teachers are not sure they are capable of controlling the situation in the class by mixing different teaching approaches, e.g., flipped classroom, project-based learning, problem-based learning, etc.

With projects such as STEAMBuilders, we enable teachers to access high-quality materials, which leads them through the whole lesson from the preparation to the main part and the reflection and knowledge retention phases. Teachers receive the

chance and the support to implement hands-on STEM lessons in their classes. By receiving easy-to-follow, in-depth, previously prepared materials, teachers feel more confident to try to use hands-on activities for teaching STEAM in their classes. In this way, they become familiar with the positive aspects of teaching STEM through hands-on activities in their classes, and they can raise awareness that STEM learning is crucial for students and also very engaging for them, helping them to always be active participants in their learning.

Hands-on STEM teaching approach give the benefits also in multidisciplinary teaching. It contains a scientific way of thinking, which can help to teach Art, history in a hands-on way. This analytical approach helps to make history lessons more innovative and not only theory but also practice. Teachers will get new ideas and directions how to compile the A and STEM in STEAM – it can be linked with Art (Newton's disk can be linked to rainbow in physics lesson or drawing in art lessons), History (Roman arch can be successfully compiled with Romans, historical architectural objects and engineering...). The sky is the limit, when we see the learning objects with STEAM perspective. In STEAMBuilders project we want to give to the teachers the power to see this link between Science, Technology, Engineering, Art and Mathematics.

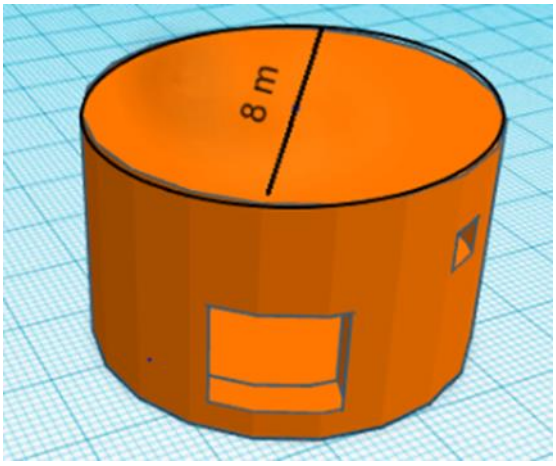


*Figure 2: From the blueprint " Build your Neolithic House" CIP, Cyprus*

# 9: Inspirational literature

| Institution | Author | Title, publisher year of publication or web. |
|---|---|---|
| | | |
| **Logopsycom** | | |
| | Anna Claybourne, Crabtree Publishing | ”Recreate Machine Innovations”<br>Grade 4 – grade 7<br>PUBLISHER: Crabtree Publishing, 2019<br>https://crabtreebooks.com/shop/show/14425 |
| | Anna Claybourne, Crabtree Publishing | ”Recreate Discoveries about Forces”<br>Grade 4 – grade 7<br>PUBLISHER: Crabtree Publishing, 2019<br>Part of the ”Recreate discoveries about…” series of classbook. (About light, Forces, Living Things, Sounds, States of Matter, , …)<br>https://crabtreebooks.com/shop/search_results?utf8=%E2%9C%93&q=scientific+discoveries |
| | Jill Staake, We are Teachers | 60 Easy Science Experiments Using Materials You Already Have On Hand<br>Jill Staake on March 2, 2022, on We are Teachers Website,<br>60 scientific experiments with things you have at home |

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| | | https://www.weareteachers.com/easy-science-experiments/ |
| **Fermat Science** | | |
| | Centre d'étude des bastides villes neuves d'Europe et du Moyen-Âge | Le livre blanc des bastides (french) Contains a lot of interesting information and many plans of the bastide |
| | IREM – coordonné par Marc Moyon et Dominique Tournès | Passerelles : enseigner les mathématiques par leur histoire au cycle 3 (French) Presentation and analysis of mathematical teaching lessons based on historical documents |
| | Antoine Houlou-Garcia | Channel Youtube https://www.youtube.com/c/ArithmAntique |
| **GoInno** | | |
| | Home - Scientix | Scientix is the number one community for science education in Europe. It aims to promote and support a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other educational stakeholders to inspire students to pursue careers in the field of **Science, Technology, Engineering and Mathematics (STEM).** |
| | Crystal Chatterton | Awesome Science Experiments for Kids: 100+ Fun STEM / STEAM Projects and Why |

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| | | They Work (Awesome STEAM Activities for Kids); book with ideas for hands-on experiments that could be implemented in school lessons |
| | Cassie F. Quigley (Author), Danielle Herro (Author) | An Educator's Guide to STEAM: Engaging Students Using Real-World Problems Reprint Edition; A guide for teachers, how to step up to STEAM teaching practice |
| **CIP- Citizens in Power** | | |
| | Designing a School Makerspace, Jennifer Cooper | An Educator's guide on how to design a space in your classroom. |
| | Wonyong Park and Hohee Cho, 2022 | The interaction of history and STEM learning goals in teacher-developed curriculum materials: opportunities and challenges for STEAM education |
| | David A. Slykhuis et al. | Teaching STEM Through Historical Reconstructions: The Future Lies in the Past, https://citejournal.org/volume-15/issue-3-15/editorial/teaching-stem-through-historical-reconstructions-the-future-lies-in-the-past/ |

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| **Trànsit Projectes** | | |
| | **ReMaking History, Volume 1: Early Makers**<br>Make Community, LLC; Illustrated edition (26 agosto 2016)<br>English<br>ISBN-10 : 1680450603<br>ISBN-13 : 978-1680450606 | William Gurstelle begins his remarkable journey through history with this volume, Early Makers. Each chapter examines a remarkable individual or group of people from the past whose insights and inventions helped create the world we live in. What sets this series apart from other history books - including other histories of technology - is that each chapter also includes step-by-step instructions for making your own version of the historical invention. |
| | **ReMaking History Volume 2: Industrial Revolutionaries**<br>Ed. : Make Community, LLC; Illustrated edición (2 diciembre 2016)<br>English<br>ISBN-10 : 1680450662<br>ISBN-13 : 978-1680450668 | Industrial Revolutionaries is the second volume in William Gurstelle's unique exploration of history's great inventors. Each chapter revisits the life and times of one of the forward-thinking revolutionaries who helped create the world we live in. You will not only learn about their great inventions, you'll also get step-by-step instructions for recreating them yourself. History will come to life as you have never experienced it before when you build it with your own hands. |

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| | **ReMaking History v3: Makers of the Modern World**<br>Ed. : Make Community, LLC (14 marzo 2017)<br>English<br>ISBN-10 : 1680450727<br>ISBN-13 : 978-1680450729 | Makers of the Modern World is the third volume of William Gurstelle's unique, hands-on journey through history. Each chapter examines a remarkable character from the past, one of the people whose insights and inventions helped create our modern world. What sets this series apart from other history books - including other histories of technology - is that each chapter also includes step-by-step instructions for making your own version of the historical invention. History comes to life in a way you have never experienced before when you follow the inventors' steps and recreate the groundbreaking devices of the past with your own hands. |
| **5th High School of Agrinio** | | |
| | https://www.youtube.com/c/STEAMspirations | STEAMspirations creates free instructional videos in English and in Spanish |
| | https://www.goodhousekeeping.com/life/parenting/g32176446/science-experiments-for-kids/ | 33 Easy Science Experiments for Kids That Only Require Household Materials |
| | https://supastem.club/bl | Free STEM Activity Book PDF for Kids. The printable PDF eBook is packed with |

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| | ogs/activity-ideas/stem-activity-book-pdf | engaging science, technology, engineering, and math challenges. |
| **Vesthim-merland** | | |
| | https://udeundervisning.dk/english | "Education outside the classroom", Webpage, A free education outside the classroom portal<br><br>**Udeundervisning.dk** is a free Danish online portal with the aim of presenting expert knowledge surrounding the teaching practice known as 'education outside the classroom (EOtC)' or 'school-based outdoor learning'. |
| | Klinge, Louise | "Lærerens relationskompetence"Dafolo 2019 (teacher relational competence ) only in Danish ! |
| | Saplagkoglu,Yasemin | **"**This Is 'Lola,' a 5,700-Year-Old Woman Whose Entire Life Is Revealed in Her 'Chewing Gum'", Live science: https://www.livescience.com/ancient-chewing-gum-reconstructs-lola.html 2019 |