

Teacher's handbook



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Introduction – about the handbook

Development Lab is an **Erasmus+ strategic partnership** developed as a follow-up of the Mind over Matter project (MoM) that ended in 2022. The idea of MoM was to develop a methodology to increase interest and motivation among young people (13 – 18 years old) to continue their education in STEM field. This was done by creating and implementing an innovative methodology with the aim to demystify science and scientific processes with the help of the Mind over Matter card game developed within the project.

After receiving feedback that educators would like to have more in-depth knowledge of the “science behind” how to run STEAM activities and guiding principles how to use the game, the decision to apply the Development Lab project was made. This project’s aim is to explore **how activities usually used in non-formal education can be adjusted to the formal education and provide meaningful experience and knowledge in STEM subjects**, as well as to **provide the critical knowledge to educators in STEM sector with the necessary knowledge and experience to run STEAM activities** using **Design Sprint** and **Challenge Based Learning** methodologies. By providing necessary knowledge and guidance to teachers, we will also facilitate providing young people with meaningful and hands-on knowledge, thus enhancing their capacity to learn STEM in an innovative way and eventually pursue successful STEM/STEAM careers.

Within Development Lab project, we have developed two types of materials for teachers:

- This Handbook which presents theoretical support and guidance for implementation of STEAM activities, describing themes such as STEAM, SDGs, public speaking, and steps of implementing makeathons
- Step-by-step guide, which provides a structured approach to guide educators through each phase of the design thinking process

This Handbook is **intended primarily for teachers**. It will serve as guidance for the implementation of STEAM activities with young people (ages 13 to 18) by providing theoretical knowledge, resources, methods and techniques to both educators/teachers and young people/students based on the synergy of Challenge based learning (CBL) and Design Thinking/Sprint (DTS).

We want this Handbook and its program to become a **universal tool in organising high-quality STEAM events** that can be transferred to other educational and cultural contexts.

Development Lab is an Erasmus+ program implemented by Šiaulių techninės kūrybos centras (Lithuania; project coordinator), Centre of Technical Culture Rijeka (Croatia), Andrija Ljudevit Adamić Gymnasium Rijeka (Croatia) and Šiaulių “Sauletekio” Gymnasium (Lithuania).



Science behind: STEAM education

Introduction

The idea that the educational system should prepare children and young people for the needs and requirements of the labour market of tomorrow has presented many challenges in the context of a highly technical, ever-changing environment of today. While 21st century skills such as problem-solving abilities, communication skills, critical and creative thinking are considered essential for successful participation in today's society, formal education often lags behind in meeting those needs, as well as in following contemporary technological advancements and changes and incorporating technology into the curriculum. STEM is today recognized as a discipline that connects various content topics and incorporates the 21st century skills. However, after being implemented for some time, STEM has suffered some critiques:

- It has been proved difficult to fully integrate different disciplines,
- Some disciplines are more easily represented than others,
- The focus on STEM causes neglect of some other disciplines

The need to re-conceptualize STEM occurred: to make it more encompassing, inclusive, flexible and appealing for those who do not have natural affinity towards natural sciences. In this regard, STEAM approach has appeared as one of possible solutions for bringing STEM closer its target groups.

STEAM education

STEAM education is a **holistic, interdisciplinary approach to learning that combines all elements of STEM – and adds to them the Arts**. It fosters creative problem-solving, collaboration and critical thinking. While STEM expressly focuses on scientific concepts, STEAM expands these concepts through the creative process. Students engage both the right (creative) and left (logical) sides of the brain to innovate and solve problems. For example, a student may learn computer programming while designing a three-dimensional model of a sculpted artwork or an educational game about SDGs.

At a practical level, STEAM education is characterized by implementing meaningful learning, eliciting students':

- **convergent thinking** (common in STEM disciplines) and
- **divergent thinking** (common in the Arts)





STEAM is also characterized by granting students an active, constructive, and critical role in their learning and fostering collaborative work, while the teacher adopts the roles of advisor, counsellor and/or guide.

The arts in STEAM education include subjects like:

Humanities, such as philosophy
Languages
Dance
Theatre or drama
Musical arts, including singing
Visual arts, such as painting
Graphic design

Students in STEAM education

Integrating arts in the traditional STEM curriculum through the STEAM approach makes students more **adaptive**:

- It teaches them to be more flexible in any given situation,
- It opens the opportunity for both teachers and students to broaden their horizons,
- It prepares them for the challenges of the real world,
- It encourages innovative thinking among students,
- It allows them to apply scientific principles and technological innovations in many artistic areas (such as in advertising, 3D modelling, and movie-making)
- It integrates the creative aspect of art to make students not mere consumers or users of technology but also creators of technology

Teachers in STEAM education

In STEAM education, teachers can have more interactive lessons that are collaborative, and project based. Students are not just absorbing the inputs from the teachers but are able to learn skills and knowledge through hands-on approach. Teachers can design lessons, projects, and modules that cross the five disciplines.

The role of the instructor in STEAM education is often described with a single word – **facilitator**. His/her responsibility is to guide and manage students in the classroom so that students are actively engaged in critical thinking and problem solving.

This usually means less teacher input than what is considered traditional. However, that doesn't mean that teachers should leave students to their own learning devices, but to



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Let them guide their learning process through generating questions and attempts to solve problems, at the same time offering direction and support.

Teachers play a critical role in **promoting curiosity, critical thinking, and problem solving** by providing an appropriate level of information, structuring, guiding learning experiences, and adjusting level of difficulty of the tasks presented. An effective teacher must, of course, know the content of his course, but simply disseminating content through direct instruction alone is no longer considered effective. To be effective, the educator must be flexible in instructional strategies and responsive to student needs as learning progresses, always with the goal of enabling students to make meaningful connections and become self-directed learners.

STEAM education from a business end perspective

From a business end perspective, the major payoffs include **better problem-solving skills and increased creativity and innovation**.

Some reports argue that, for the IT workers of the future, creativity is a key priority and that STEM educators need to embrace the arts to foster students' creative design and performance, using various media. Designing engaging solutions requires creative talent, and creativity is also critical in ideation.

The integration of arts into STEM education and fields may also help encourage **more participation by women** in what have been male-dominated areas.



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Sustainable Development Goals (SDGs)

Sustainable Development Goals (SDGs) or **Global Goals** are a collection of seventeen interlinked objectives designed to serve as a **“shared blueprint for peace and prosperity for people and the planet, now and into the future.”** They emphasize the interconnected environmental, social, and economic aspects of sustainable development by putting sustainability at their centre.

The SDGs were created in 2015 by the United Nations General Assembly (UNGA) and formally articulated and adopted in a UNGA resolution known as the 2030 Agenda. The plan is to achieve most of the targets by 2030, although some have no end date.

In this methodology, we use SDGs as starting point for the research for several reasons:

1. They are real world problems, and they enable young people to get engaged around existing challenges with already generated scientific research. Their research and contribution to solving defined Global Goals enable young people to engage in a meaningful research task.
2. They cover all possible areas of STEM and from them many STEAM projects can be easily generated. Many of those are oriented towards humanity, they don't stress STEM as their starting point, so they can engage young people who are more interested in humanities and social sciences.
3. Young people with different interests can find themselves easily attracted to at least one of the SDGs if not more of them. Their interest in the field is a prerequisite for engagement in the learning process and successful attraction to STEM using STEAM approach.
4. We want future generations of young people to know them and be aware of them in their future life. Only with joint efforts we can achieve them and support future of our planet.

17 Sustainable Development Goals

1. No Poverty

End poverty in all its forms everywhere.

We all have the right to food, water, health, education and housing, to live without fear, not to be discriminated against, to participate in decisions that affect our lives, and to get justice when these rights are violated. Poverty is a key reason why these rights are violated. And, it is not just about how much money people earn. It means not having clean water or enough food to eat, not having a proper roof over your head, not getting good healthcare when you need it, or not being able to send children to school. It means being denied access to all the resources, services, skills, choices, security and power that we all need to realize our human rights. It means marginalization and discrimination.



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2. Zero Hunger

End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Today the world produces more food per person than ever before, but there are still people that are hungry. Actually, the number of people affected by hunger globally has been slowly on the rise since 2014 and the main reason is that not everyone has the same access to food. Poor people spend most of their money on food. When the price of food increases, they are forced to skip meals or buy food that is cheaper and less nutritious. This has significant impact on health of individuals around the world, and especially on children. There are millions of kids under age 5 that suffer from stunting (low height for age) or on the other hand millions of kids being overweight due to the unhealthy food consumption. But food insecurity has consequences on many other areas of development like education and employment. That's why eradicating hunger and malnutrition is one of the great challenges of our time.

3. Good Health and Well-being

Ensure healthy lives and promote well-being for all at all ages

If the world, as a whole, would think of investing in something for creation of better world tomorrow, the one thing we should all put our time and energy in is our health. While health is a global problem, each region faces its own problems. Some of the biggest issues are reproductive, maternal, newborn and child health, as well as chronic and infectious diseases, mental health, safety accidents and substance abuse. Today, probably more than ever for our generation, it is clear that we need to have knowledge to prevent sickness and diseases. Having more informed individuals on the topics of health and well-being can prevent sickness and diseases. Investing in these will not only make us healthier, but we will be richer and happier.

4. Quality Education

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Education gives people power. That power lies in its potential to change people, communities, entire nations and the future of humanity. It provides better opportunities, jobs and lives in general. Educated individuals and consequently educated communities can come up with a variety of ideas and can lead to more informed and responsible decisions. It is fundamental in escaping chronic poverty, it can help us be healthier, empowered, employable and it is vital for economic and sustainable growth. Education can create positive synergies and make us believe that we are not helpless, that change is possible, and that we can drive it.



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5. Gender Equality

Achieve gender equality and empower all women and girls

Girls and women remain deprived of full and equal opportunities. They represent the majority of people who live in poverty, who are subject to discrimination and gender-based violence, and who are less likely to have access to services, including education. Gender equality is essential for protecting universal human rights and fundamental freedoms. It is also a powerful development accelerator. The education of girls and women can lead to a wide range of benefits – from improved maternal health, reduced infant mortality and fertility rates to increased prevention against HIV and AIDS. For this to happen, we need to target the gender gap at every level.

6. Clean Water and Sanitation

Ensure availability and sustainable management of water and sanitation for all

“Water is life.” This saying is widely used in some of the most water-stressed nations in the world, particularly in sub-Saharan Africa. Every year, millions of children suffer from preventable illnesses. Without access to clean water, safe sanitation and hygienic practices, they die from diseases like diarrhea that are otherwise preventable and treatable. Safe water and adequate sanitation facilities are crucial for health and survival. Lack of access to these is the world’s single largest cause of illness. There are a number of reasons for this, water pollution is just one reason.

7. Affordable and Clean Energy

Ensure access to affordable, reliable, sustainable and modern energy for all

Although we have made great improvements towards improving access to electricity and use of renewable energy, the world is still short of achieving affordable, reliable, sustainable and modern energy for all. By turning to the renewable energy sources, we are saying no to climate change and deforestation. Increasing the supply of renewable energy allows us to replace carbon-intensive energy sources (e.g. fossil fuels) and reduce greenhouse gas emissions. Renewable energy is the cornerstone of a future of human prosperity without environmental sacrifice.

8. Decent Work and Economic Growth

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Being safe and paid fairly to provide for yourself and your loved ones is what we all hope to get from our job. But not all of us achieve the goal.



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Over the past 25 years the number of workers living in extreme poverty has declined dramatically, despite the lasting impact of the 2008 economic crisis and global recession. However, we are seeing slower growth, widening inequalities, and not enough jobs to keep up with a growing labour force. Encouraging entrepreneurship and job creation are key to this, as are effective measures to eradicate forced labour, slavery and human trafficking.

9. Industry, Innovation and Infrastructure

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Take a moment and try to imagine your life without the roads, electric energy or Internet. They are essential for a prosperous and sustainable society. In many developing countries and in rural areas of the developing countries, millions of people don't have resources to agricultural production, telephonic services or roads. Investment in infrastructure and innovation are crucial drivers of economic growth and development. Technological progress is also key to finding lasting solutions to both economic and environmental challenges, such as providing new jobs and promoting energy efficiency.

10. Reduce Inequalities

Reduce inequality within and among countries

In today's world we are all interconnected. Despite some positive signs toward reducing inequalities in some dimensions, inequality still persists. Daily we are witnessing consequences of gender, age, income, disability, sexual orientation, class, nationality, ethnic origin or religion inequalities. Global inequality has an impact on growth, encourages poverty, delinquencies and illnesses. Inequality within and among countries is a persistent cause for concern. Reducing and ensuring social equality in which people have the same status in respect to civil rights, freedom of speech, property rights and equal access to social goods and services is integral part of assuring better tomorrow.

11. Sustainable Cities and Communities

Make cities and human settlements inclusive, safe, resilient and sustainable

Cities and communities are at the fore of sustainability challenges of the twenty-first century. But what does it mean to be sustainable city or community? A sustainable city/community is one that respects sustainable development priorities from their social, economic and environmental perspective, and that allows its inhabitants to live in good conditions and in harmony with their surrounding nature. Providing universal access to safe, inclusive, accessible, and green public spaces by 2030, especially for the most vulnerable groups is essential to make sustainable development a reality at local level.



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12. Responsible Consumption and Production

Ensure sustainable consumption and production patterns

By changing our perspective and mind-set about how we make and consume stuff we can help our planet and ensure better quality of life for ourselves. Understanding circular economy as our priority in terms of consumption and production can help us achieve it because it is based on creation of goods and services using processes and systems that are non-polluting, that conserve and preserve energy and natural resources, that are economically viable, safe and healthy for workers and consumers, and that are socially and creatively rewarding.

13. Climate Action

Take urgent action to combat climate change and its impact

Global climate change has made glaciers shrunk, ice on rivers and lakes break up earlier, plant and animal ranges shift and trees flowering sooner. The consequences are not only that; they can be disastrous. Disaster can become even greater when we are not prepared for them - when people lack preparedness or the ability to cope with hazards. Climate change is the single biggest threat to sustainable development on our planet and its hardest the poorest and most vulnerable groups. That's why urgent action is needed.

14. Life Below Water

Conserve and sustainably use the oceans, seas and marine resources for sustainable development

In the last few decades we have exploit ocean resources more than ever before. Our behaviour towards the biggest world ecosystems that provides us food, materials substances and energy is not acceptable. We dump garbage, plastic, military munition, toxic chemicals, nuclear waste and other disgusting things to our oceans pretending like we're not in hot water. If we want to continue to use the ocean wealth we need to restart ourselves and begin to act responsibly to the oceans.

15. Life on Land

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

The health of the planet should be at the centre of all our plans and policies since we don't have another one. Ignoring the consequences of deforestation, biodiversity loss and ongoing degradation of ecosystems already now has a great impact on our planet and our communities. Promoting a sustainable use of our ecosystems and preserving biodiversity is not a cause, it should be our lifestyle.





16. Peace, Justice and Strong Institutions

Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Millions of people today live in fragile and conflict affected states. It is important that governments, civil society and communities work together to implement lasting solutions to reduce violence, deliver justice, combat corruption and ensure inclusive participation at all times. Promotion of the rule of law together with strong and independent institutions can ensure equal access to justice for all.

17. Partnership for the Goals

Strengthen the means of implementation and revitalize the global partnership for sustainable development

The last sustainable development goal is the goal that can assure achievement of all other goals – if we all work together we can make great things happen.



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Sustainability Mindset

Sustainability Mindset is the one that **engages emotionally, intellectually, and responsibly with sustainability issues** and can look critically at current norms and behaviours that negatively impact people and planet. It is a way of thinking and being which results from a broad **understanding of the ecosystem, social sensitivity, and an introspective focus** on personal values and the higher self.

A sustainability mindset goes beyond merely acknowledging environmental issues; it involves being deeply aware of the interconnection between ecological balance, social equity, and economic prosperity. It means making conscious decisions that consider the long-term impact of our actions on the planet, people, and future generations.

It is a way of life that can redefine the future of our planet.

Until recently, the future of our planet and of humanity itself seemed to be not a problem for individuals, but only for institutions and national and international politics. Today, however, we cannot ignore what events and science show us every day. Building and spreading a culture of sustainability today contributes to building a more liveable future for all. The environment is a precious resource and defending it is a mission for everyone. Therefore, a sustainable mindset needs to be developed, to make people and companies capable of thinking and then applying the concept of sustainability in their daily lives. That's why the educational and cultural system must be revolutionised.

There are two ways in which education for sustainability can be approached:

- 1) **External approach** (from the perspective of knowledge, competencies, and skills): this perspective focuses on enriching and expanding the knowledge base and developing individual mastery in subject areas. Individuals learn and become more proficient while staying within their way of seeing the world.
- 2) **Internal approach** (focuses on individual values, beliefs, assumptions and thinking processes, as well as on collective paradigms and worldviews): individuals here learn to become aware of the lens through which they see the world and are able to revise it, see it critically and identify alternatives. This approach to education for sustainability is developmental and it prompts transformative learning.



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Examples of a sustainability mindset

Greata Thunberg (Sweden) – this young environmental activist exemplifies a strong sustainability mindset by advocating for urgent climate action and inspiring youth-led movements worldwide

LEGO group (Denmark) – The LEGO Group’s sustainability mindset includes using plant-based materials in bricks and exploring sustainable packaging to reduce its environmental impact

Ugly Juice (Singapore) – Ugly Juice rescues “ugly” and surplus fruits, transforming them into nutritious cold-pressed juices, reducing food waste and promoting sustainability

Importance of sustainability education

There are many reasons why sustainability education is important for the next generation:

1) ENVIRONMENTAL AWARENESS

Sustainable education helps students develop a **deeper understanding of the environmental challenges** being faced by nations globally. It forces **awareness** about climate change, biodiversity loss, deforestation, resource depletion, food and water scarcity and other challenges and builds knowledge which will help the next generation to devise sustainable solutions.

Sustainable education builds an understanding of:

- The principles of sustainable development,
- How they can be implemented,
- The values involved, and
- The ramifications of their implementation.

According to UNESCO, building environmental awareness in students helps:

- To make them more **conscious and mindful** of the environmental problems
- To **boost** their **interest** in caring for and improving the environment
- To **enhance** their **ability** to learn about their surroundings
- To **broaden** their **ecological knowledge** (about energy, landscapes, air, water, natural resources, wildlife, etc.)





2) ENHANCES CRITICAL AND CREATIVE THINKING SKILLS

Today's children and young people are tomorrow's leaders and decision makers, which is why it is important to help them learn how to **investigate and understand why things happen and make their own decisions** about complex environmental issues. By enhancing critical and innovative thinking skills of young people, we will foster a new generation of informed consumers and decision-makers. Also, sustainability issues are complex and need to be seen from different perspectives. Sustainability education helps students **look at the bigger picture** and develop these skills along with a system thinking approach in students.

3) BUILDS SUSTAINABLE LIFE SKILLS

Sustainable education drives sustainable thinking which influences the way young people feel and behave towards the environment and its challenges. It builds the **following skills** in students:

- The ability to effectively communicate orally and in writing
- The ability to think about systems and processes
- The ability to forecast, think ahead, and plan
- The ability to think critically
- The ability to use multiple perspectives to understand another person's viewpoint
- The ability to analyse values underlying differing positions
- The capacity to move from awareness to knowledge to action
- The ability to work cooperatively with other people
- The capacity to lead, establish visions, act ethically

4) HELPS UNDERSTAND HUMAN-NATURE RELATIONSHIP VALUES AND PRINCIPLES

If we want to build an environmentally sustainable world, we must understand the **values upon which the relationship between humans and nature thrives**. Documents such as [Earth Charter](#) and the [Rio Declaration](#) list such values and principles.

5) PREPARES FOR THE FUTURE

Sustainability deals with environmental, socio-economic, and political problems that communities face around the world. Sustainable education in school teaches students how to **analyse issues** and **untangle the complexities of sustainability issues** that their communities will face in the future.





Students learn to create different environmental, social, and economic solutions that are locally viable while at the same time looking at the bigger picture (e.g. cleaning up local pollution without shipping toxic and hazardous waste to another country).



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Public speaking and pitching

When you present your projects and ideas generated through participation in Makeathons, you have to find the most simple and direct ways to tell the audience what you have been doing during the course of the event, what you created and why you chose that particular solution. Presentations need to be adjusted to the audience, well organized, concise and to the point, with all the most important points well outlined and explained. **Several minutes that are at your disposal for presenting your idea/project/solution need to be used in the best possible way.**

Knowing how to present your ideas in a successful way can help you share them with any audience, and help you develop the audience for future public appearances.

Here's a couple of **public speaking tips** to help you create a strong presentation and wow your audience:

1. **Talk about what you know:** the audience will feel your knowledge and passion for the topic, and you will feel less anxious knowing that you have a lot of knowledge or experience to draw from.
2. **Practice:** even great speakers practice their speeches beforehand. Practice out loud in front of someone you trust and feel comfortable with or record yourself speaking and watch/listen how you can improve.
3. **Concentrate on your message:** when you focus on the task, you are less likely to develop anxiety.
4. **Grab the audience's attention:** most of your audience (for example, pupils or classmates) will pay attention for at least the first 20 seconds of your presentation – grab their attention during that time. Start with an interesting fact or a story that relates to your topic.
5. **Have one main message:** focus on one central theme and the audience will learn more than if you try to cover too much ground.
6. **Tell stories:** stories catch the audience's attention and deliver a message in a more meaningful way than facts and figures. Whenever possible, use a story to illustrate a point in your talk.
7. **Organise your talk:** every speech should have an introduction, a body, and a conclusion.
8. **Find a friendly face:** if you are feeling anxious, find one friendly face in the audience and imagine that you are speaking only to that person.
9. **Develop your own style:** let your personality show through your speaking style and you will feel more comfortable in front of the audience.



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10. **Make the audience laugh:** laughter is a great way to relax both you and your audience, and telling jokes can be a great icebreaker at the beginning of a speech.
11. **Smile and be positive:** the audience will perceive you as a warm speaker and be more receptive to what you have to say.

Creating a winning Makeathon pitch

The time to present your pitch is limited, so make every second count. If you structure your pitch beforehand, this will help you organize your ideas and make sure you don't leave out any important information.

If possible, practice the pitch a few times – this will help you remember the most important points and increase your comfort level when it's time to deliver your pitch. Save enough time to explain the core technical side of the project, your decision-making process and a demo of your solution.

Considering most Makeathon pitches last around 3 minutes, here's an idea on how it could be formed:

1. **Introduction (10 seconds):** introduce yourself and your team in a way that's memorable. People recall more easily how things start and finish, so make sure they remember you and your team when they are deliberating.
2. **Problem statement (20 seconds):** what problem are you trying to solve? Whose lives can be improved? What impact can your solution bring? Don't forget to convey impact to what you are saying.
3. **Solution (1 minute):** explain the technical aspects of your project. Focus on providing enough information to showcase your technical competence and decision-making process without getting lost on the details or overwhelming your audience.
4. **Demo (1 minute):** support your product presentation with a live demo (if applicable) or visualization tools to mock-up the design, functionality, and the main key features of your solution.
5. **Wrap-up (30 seconds):** summarize your key points and end with a strong closing statement.





How to plan and organize Makeathons in schools

What exactly is a Makeathon?

Makeathon is an **(usually) intensive event whose objective is to increase motivation among children, young people or adults for the STEM fields** (Science, Technology, Engineering, Mathematics) **by creating and implementing an innovative, hands-on, inquiry-based methodology that will demystify science and scientific processes**. The process can be enriched by integrating Arts into the project (STEAM), in which case creativity and imagination become central to the design process and introduce scientific practices to participants who are naturally more inclined towards creative school subjects. It integrates arts thinking with scientific thinking, and removes the artificial barrier between them.

Organisation of Makeathon

A Makeathon focuses on the process of collaborative problem solving and creative technology approaches to grand challenges. It has to have its topic or challenges.

Here are suggested numbers of people involved in Makeathon organized for **25-60 young people (13 - 18 years old)**:

- Number of mentors – 5-12 mentors (1 mentor for a group of max. 5 students)
- Number of inspirational speakers – 2 to 4
- Makeathon leader – 1 to 2 persons
- Jury members – at least 3 (it has to be uneven number)

Makeathons in schools can be arranged in different ways to fit into the regular school activity - as one intensive event, in weekly or monthly intervals:

- **Intensive event:** if possible, the event can be organized in its original form. This event lasts for few days (3 to 5). Since you are working with young people, the workload is around 6 to 8 hours involving breaks for lunch, rest, and some free time.
- **Weekly intervals:** the event can be included into the regular workload of a class by defining one day of a week dedicated to the implementation of one (or more) parts of the process. In this case, you may need less mentors, the teacher can take over the role of the Makeathon leader, while inspirational speakers and jury members only need to appear at a certain week, according to how the process is divided. Expected workload per week is around 1 -2 school hours.
- **Monthly intervals:** defining one day per month is another way of including the process into the regular curriculum and workload of a class.



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The event, regardless of the way it is arranged, should be in a form of a competition of a sort, and at the end of the event you need to declare the winner (the best team). The decision is made by the jury.

Materials used in Makeathons

You want to implement a Makeathon in your school but are afraid that you don't have all the expensive materials and tools that participants will need during the course of developing their solutions and projects?

Don't let that stop you. There are no strict rules in what materials can be used, since the process of developing projects in a Makeathon is so open that you can never know what a group will find useful when creating their solutions.

Gathering necessary resources and materials

Here are some tips on how to gather the necessary resources and materials for your Makeathon:

1. **Determine what materials are needed:** Consider the type of projects that will be worked on during the Makeathon and create a list of necessary materials.
2. **Estimate quantities:** Estimate quantities of each material needed based on the number of participants, the number of teams, and the expected duration of the Makeathon. It's better to have too much than too little, so be generous with your estimates.
3. **Source materials:** Look for suppliers that can provide the materials you need. You can also ask for donations or partnerships with local businesses or organisations. Consider borrowing materials or renting them if needed.
4. **Ensure proper equipment:** Make sure that all equipment and tools are in good condition and work properly before the Makeathon begins. Check the equipment and tools regularly during the event to ensure that they continue to function properly.
5. **Organise materials:** Organise materials so that they are easy to find and use during the Makeathon. Use clear labels and storage containers to keep everything organised.
6. **Provide safety equipment:** Provide appropriate safety equipment for any hazardous materials or tools used during the Makeathon. Make sure that all participants are aware of safety protocols and that they follow them.
7. **Provide technical support:** Provide technical support for any tech equipment used during the Makeathon. Make sure that participants are aware of the technical support available to them and that they know how to access it.





Some examples of materials used in Makeathons

<p>Paper</p> <p>Glue</p> <p>Scissors</p> <p>Post-its</p> <p>Pens</p> <p>Pencils</p> <p>Markers</p> <p>Scotch tape</p>	<p>Hot glue gun</p> <p>Recycled materials (bottles, bottle taps, egg cartons, cardboard, paperboard core of toilet paper, bubble wrap, plastic cups, paper cups, etc.)</p> <p>Wooden slats and boards</p> <p>Rope</p> <p>Wire</p> <p>Rubber band</p> <p>Mesh, net</p> <p>Rocks, stones, sand</p>	<p>Batteries</p> <p>Microchips</p> <p>Magnets</p> <p>Different tools (hammers, pliers, etc.)</p> <p>3D printers</p> <p>Plywood cutter</p> <p>Sander</p> <p>Handsaw</p> <p>Spray paint</p> <p>Scalpel</p> <p>Nails and screws</p> <p>Electrical components (resistors, wires, sensors, etc.)</p> <p>Computers</p>
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Roles of involved personnel

There are four roles of personnel involved in the implementation of a Makeathon:

1. **Makeathon leader** – this a host of the event. This person's role is to host the event and to inform all participants about the goals, rules, timeline and everything concerning the event. This person knows the timeline and can always give information to participants. He or she needs to be a resourceful person connecting the Makeathon participants and Makeathon organizers. In a schools setting, working with one class of students, a main teacher is Makeathon leader.
2. **Mentors** – they are educational experts that are well acquainted with the pedagogy or andragogy and also experts in the field of STEM, technology or Art connected to the Makeathon topic. They are always there, and their role is to facilitate the development of the solution. Their skills and expertise are presented to whole group at the beginning of a Makeathon and they are involved upon request of a specific group. Nevertheless, they are going from one group to another and ask if the group need a support. Also, mentors discuss group progress between themselves the whole time and offer support when they see the group need a guidance to move forward.



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Therefore, in case a Makeathon is implemented in weekly or monthly intervals, and the group works on a project outside of a school setting, mentors must be available upon request. Joint meetings of all mentors with all groups must be organized on a weekly or monthly basis.

3. **Inspirational speakers** – they are experts/innovators on the topic of the Makeathon. Their role is to inspire participants. They can have a short presentation, inspirational speech or just be there and talk to the participants. They can, but don't need to be there all the time. They are experts outside the classroom/organization, from the academia, public or private sector.
4. **Jury** – they are outside the organization experts that are going to decide whose solution has the best answer to the topic/challenges of the Makeathon. They can come on a last day if decision is made by evaluation of prototypes/solutions developed. If a teamwork is evaluated, members of jury have to attend a Makeathon several times.

Logistical organization of the event

In terms of organizational needs, the organizer needs to think about the following:

- **Program** – the program needs to be defined in advance. It needs to have an introduction stage (defining what is Makeathon and what the general process will look like), challenger stage (presentation of the challenges), team forming stage (teams forming, they need to be well balanced with the skills), experimentation stage (brainstorming, trying different solutions and trying to choose the best idea solution), development stage (team work on the solution they choose), presentation stage (presentation and performance of each team's result and award ceremony) and wrap-up stage (the host presents some concluding remarks).
- **Awards** – it depends on the budget, but for sure there should be an award at least for the winning team. It is good when it is connected to the topic of the event or with further development of their idea, knowledge etc.
- **Equipment** – it depends on the topic/challenge of the Makeathon. It needs to be something that your personnel know to use. It can be something you already have. Usually what we use is: computers, projectors, charts, wood saw, 3D printers, mBots, micro:Bits,
- **Materials** – it depends on the topic/challenge of the Makeathon. Usually we use: plastic for 3D printers, batteries, plywood, paper, coloring materials, recycled materials (plastic bottles, different containers, cardboard, etc.)
- **Premises** – there should be enough space for participants to work in groups, but also to accommodate their time for fun and rest. They can be in different rooms, but also in the same. If there is a need, they can also go outside. *When done in schools, classrooms can be used, as well as communal areas – depending on the size of the group (whether it is one class or more) included in the activity.*





- **Food and beverages** – if you decide to implement the Makeathon as an intensive event, you need to organize lunch for all the participants and also have some snacks for breaks. Beverages should be there free for the taking for all participants, at all times.
- **Accommodation** – if you are inviting participants outside your local community you need to organize accommodation for them. Since they are minors you need to organize someone to look after them for the time not concerning the Makeathon.

Selection of participants

The event can be organised in one or more classes of one school, in which case all students are part of the Makeathon. Another possible approach is to organise Makeathon in a school inviting students to apply for a participation or invite students from more than one school.

When doing the selection of participants, it is important to ask two questions – why you want to participate in Makeathon or what is motivating you to apply for it and another important question is what you are passionate about, what are your hobbies or superpowers you can give to your team. This will enable you, as an organiser, to select students with different level of motivation and different sets of skills and passions.

Tip: don't be afraid of students who have low motivation for school activities or intent to skip whatever they can. They have proven to be highly engaged in Makeathon activities and they will surprise you.

Promotion of the event

The event should be promoted among **participants** and the **public**.

To involve the participants you can do different types of activities:

- You can have an **open call for participants** through your usual communication channels such as your website, social networks, newsletter, mailing lists or media appearances. The call needs to be open at least a month before.
- You can have a **focused call among participants of your other activities**. Then you need to communicate the event with them and see who is interested. You can do that through face-to-face communication, but also through the mailing list or other communicational channels that you use to communicate with them (for example Viber, WhatsApp or Facebook group).



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- You can **cooperate with other schools to organize the event**. Then you need to create a proposition for collaboration and define what are your roles (to organize the event) and what you expect from schools (to collect interested participants).

Promotion to the public can be organized in different scopes depending on the needs of the event – from inviting people to the event (parents, representatives of the community, media representatives) to just informing public about the event through your communicational channels. It depends on your capacities and nature of the event.

We recommend inviting guests and media to the final event to give the pitching part more excitement and students an opportunity to present their work not only to their friends and jury, but also to other important people and community in general.

The process of implementation of Makeathon

1. Introduction

Participants begin by introducing themselves, saying what they believe they are good at and can contribute to a group and also nominate an issue that they feel passionate about (accessibility, climate, animal welfare, music education in schools, gaming, football etc...)

2. Group formation

Participants are allocated a group membership by random numbering to avoid clustering of friends and to reinforce the variety of specialisms and interests.

3. Group roles

One participant in each group is designated by the group as a Scribe. Their role is to take notes and record the group's progress. Another participant is designated as the Timekeeper. Activities and sprints during the Makeathon can be set (eg: For the next 10 minutes, brainstorm... etc.) and the Timekeeper is responsible for ensuring the group stays on track. A third group participant is nominated as the Spokesperson. When presentations are made to the entire room, this person speaks on behalf of the group. These are must have roles in the group. If you have bigger groups, then you are free to appoint other roles to the team members, e.g. The Mayor should take charge of making sure that the best ideas are being worked on. They should be assigning tasks to the other group members. The Professor should be in charge of researching the challenge and finding technical solutions to problems that arise during prototyping. They should be knowledgeable and able to provide technical guidance to the group.





The Jester is in charge of encouragement and motivation, keeping everyone's spirits up and generating creative ideas. They should aim to be the most creative (and funny) during brainstorming sessions, providing provocations and 'what if' scenarios.

4. Forming a challenge

A leader of Makeathon together with mentors should define the way challenge will be formed. It can be internally pre-defined or can be defined by the participants.

- Internally pre-defined challenge

When challenge is pre-defined it can be defined in a form of question or general theme on which participants have to come with a prototype as a solution. Solution can be created in competitive or collaborative way.

In case of competition each group is forming their own prototype, while when cooperating each group is forming one part of prototype or solution which has to function when finished.

- Challenge defined by participants

In the Mind over matter project, the predecessor of Development Lab, we developed a card game which can be used for forming the question by participants. Cards can be used in a form they are now, can be preselected or as an inspiration for development of other cards connected to the theme of Makeathon. The cards are divided into 3 decks, each representing one of the elements whose combination will form a question, that is, the challenge: 1) Arts, 2) Careers, 3) SDG's.

Developed cards are available online: <https://steamproject.eu/cards/>

In the case of using cards, the process is as follows:

Card selection

Each group selects a card at random for each category and the Scribe notes the list of cards selected. 5-10 sets of cards must be drawn. Students are given 3 minutes to discuss what these cards suggest, the kinds of questions that may arise, and what sorts of projects the group can imagine being made in response to that challenge. This activity is repeated 5 to 10 times, and the Scribe should end up with a list of 5-10 sets of cards from which challenges and guiding questions can be formulated.

Groups are then given 5 minutes to discuss and asked to rank the combinations from easiest to hardest (numbering them 1 to 5/10) in terms of their perceived level of difficulty to combine the cards and make a good project inspired by that selection.



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These are shared on a whiteboard for the entire room to discuss and reflect upon (10 minutes).

The Makeathon leader then assigns them all a particular ranked set as their challenge to work on. We found that telling the students that they must work on the 'second hardest' group of cards (ranked 4 or 9) was accepted by the students as both a challenge and a relief that they were not assigned the hardest set.

5. Initial question formulation

Participants are asked to create a question based on the challenge or cards that they have been allocated. In case of cards, they should be told that the question only needs to be inspired by those cards and the words in the cards do not all necessarily have to appear in the question. The cards are a thinking tool to open ideas, not a prison that they must endure.

6. Research

Participants are asked to spend 30 minutes researching the challenge/cards that they have (Wikipedia, Google, etc.) The group is asked to find information about theme or terms, roles, and SDGs on the cards, that they find particularly interesting, surprising, or challenging. The group is asked to collate (and the Scribe to write down) as much information about challenge or each of the cards assigned as they possibly can in the time allocated.

7. Word association (only in case of using cards)

Participants are asked to spend 2 minutes per card writing down as many associated words, concepts or ideas that come to mind when they think about the word(s) on the card. For instance, if the word is 'sculpture', they may think of clay, museum, public art, thinker, stone, chisel, build, cut, etc. Students are then asked to include the issue that they said they were passionate about in the initial introduction. They are encouraged to spend another 2 minutes each on these words and concepts to find related concepts and possible points of connection. The purpose of this exercise is to enable the students to think more broadly around the cards that they have been assigned so that the challenges and prototypes that they create may be something that is inspired by the card methodology rather than dictated directly by the words that appear in the cards.

8. Question formulation /Problem formulation

Using the research and, if applicable, the word association with card concepts and participants' passions, the participants are then invited to reformulate their initial question and develop it in a way that reflects a challenge that they are invested in finding a solution to.



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9. Ideation

In this step, participants are invited to involve in the creative process of generating, developing and communicating new ideas relating to the question/problem and possible solutions. There are a number of techniques that can be used to facilitate this process: brainstorming, idea mapping, sketching, the 5 whys technique, etc. At the end of this step, each group should have a clearly defined final idea that they will work on and realize.

10. Prototyping

Participants develop their chosen solution, that is, they implement their idea(s) from the previous step into tangible forms. These can include paper solutions (sketches), digital solutions (PPT presentations elaborating the prototype) or physical, 3D solutions. The form depends on the creative process of the group and the rules of the event. A natural part of the prototyping process is iteration – the method of creating and testing solution in small, incremental stages before finding the best option.

11. Mentorship

Each participants group is assigned another participants group to mentor. For example, Group 1 mentors Group 2, Group 2 mentors Group 3, Group 3 mentors Group 1. 30 minutes is allocated for mentorship during which time the role of the mentoring group is to attempt to question and improve the challenge created by their mentees. Groups are then asked to reflect on whether and how their question might change. Mentorship sessions are then regularly assigned during the program. In developing this methodology, we found this not only built social connections and improved the quality and ambition of the projects but also fostered a collaborative environment rather than a competitive one, in which all students were keen to help each other succeed to the best of their ability.

12. Inspirational injections

Each morning, students were invited to listen to a guest speaker or video of a presentation that would give them new ideas for their work and explain new ways of thinking about using technology and creativity to address grand societal challenges. The aim is to show videos or invite local guest speakers or other ways of providing inspirational and instructional input that can improve the students' thinking about their projects.

13. Presentations/competition

The final step of a makeathon is the presentation of group solutions, which can be done in an exhibitory manner or as a competition.



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This stage gives the chance to all groups to present what they've been working on to their peers, families or a jury that will decide on the best solution (and the best group) and shouldn't be skipped, since it gives the sense of validation and importance of all the hard work that was put into the participants' projects.

Apart from boosting the confidence and satisfaction of the participants, this is a phase which also motivates them to think about the solutions they have developed and pitch them in the most appropriate and attractive way. Through this process, skills such as public speaking, pitching and conveying information are developed.





Challenge based learning: introduction

Before we go you may probably have a question in mind “What is the difference between Problem-based learning and challenge-based learning?” Challenge-based learning and project-based learning are both instructional approaches that promote active learning and student engagement. However, they differ in terms of their focus, structure, and outcomes.

Challenge-based learning is a teaching approach that starts with a complex real-world problem or issue, which students investigate and attempt to solve collaboratively. The focus is on developing childrens' critical thinking and problem-solving skills, as well as their ability to work in teams, communicate effectively, and take action. The process usually involves several stages, including identifying the problem, researching the issue, developing and testing solutions, and reflecting on the learning process. The outcome is often a proposed solution or a plan of action to address the problem.

Project-based learning, on the other hand, is a teaching approach that involves students working on a specific project or task for an extended period of time, often several weeks or months. The focus is on developing students' knowledge and skills in a particular subject area, as well as their ability to work independently, manage their time, and present their work. The process usually involves several stages, including planning, research, implementation, and presentation. The outcome is often a product or artifact, such as a model, a report, or a presentation.

What is CBL?

Challenge Based Learning provides an efficient and effective framework for **learning while solving real-world Challenges**. The framework is **collaborative** and **hands-on**, asking all participants (students, teachers, families, and community members) to identify Big Ideas, ask good questions, discover and solve Challenges, gain in-depth subject area knowledge, develop 21st-century skills, and share their thoughts with the world.

The Challenge Based Learning framework emerged from the “Apple Classrooms of Tomorrow—Today” (ACOT2) project initiated in 2008 to identify the essential design principles of a 21st-century learning environment. Starting with the ACOT2 design principles, Apple, Inc. worked with exemplary educators to develop and test Challenge Based Learning.



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Challenge Based Learning builds on the foundation of experiential learning and leans heavily on the wisdom of a long history of progressive ideas. The framework is informed by innovative ideas from education, media, technology, entertainment, recreation, the workplace, and society.

The Challenge Based Learning Framework divides into three interconnected phases: **Engage, Investigate, and Act**. Each phase includes activities that prepare the Learners to move to the next stage. Supporting the entire process is an ongoing process of documenting, reflecting and sharing.

The process of CBL

Phase 1: Engage

Through a process of Essential Questioning, the Learners move from an abstract Big Idea to a concrete and actionable Challenge.

1. **Big Ideas** are broad concepts that are explored in multiple ways and are relevant to the Learners, and the larger community (e.g. health).
2. **Essential Questioning** allows the Learners to contextualise and personalize the Big Idea. The end product is a single Essential Question that is relevant to the individual or group (e.g. What do I need to do to be healthy?).
3. **Challenges** turn the Essential Questions into a call to action by charging participants to learn about the subject and develop a Solution. Challenges are immediate and actionable.

Phase 2: Investigate

All Learners plan and participate in a journey that builds the foundation for Solutions and addresses academic requirements.

1. **Guiding Questions** point towards the knowledge the Learners will need to develop a Solution to the Challenge. Categorizing and prioritizing the questions create an organized learning experience. Guiding Questions will continue to emerge throughout the experience.
2. **Guiding Activities and Resources** are used to answer the Guiding Questions developed by the Learners. These activities and resources include any and all methods and tools available to the Learners.



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3. **Analysis** of the lessons learned through the Guiding Activities provides a foundation for the eventual identification of Solutions.

Phase 3: Act

Evidence-based Solutions are developed, implemented with an authentic audience, and then evaluated based on the results.

1. Solution concepts emerge from the findings made during the investigation phase. Using the design cycle, the Learners will prototype, test and refine their Solution concepts.
2. Implementation of the Solution takes place within a real setting with an authentic audience. The age of the Learners and the amount of time and resources available will guide the depth and breadth of the implementation.
3. Evaluation provides the opportunity to assess the effectiveness of the Solution, make adjustments and deepen subject area knowledge.

Each of the phases and the steps are explored in greater detail in chapter three. Before diving deeper into Challenge Based Learning, some thinking about planning and preparation is necessary.



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Design thinking

There's no single definition for design thinking. It's an idea, a philosophy, a strategy, a method, and a way of seeing the world. It's grown beyond the confines of any individual person, organisation or website. And as it matures, its history deepens and its impact evolves. Basically, design thinking is **a way to solve problems through creativity**. Certainly, it isn't a fail-safe approach; nor is it the only approach. But based on the impact being seen around the world and solutions it has provided, the relevance of design thinking has never been greater.

However, if we try to summarise and give one solid definition, it could look like this:

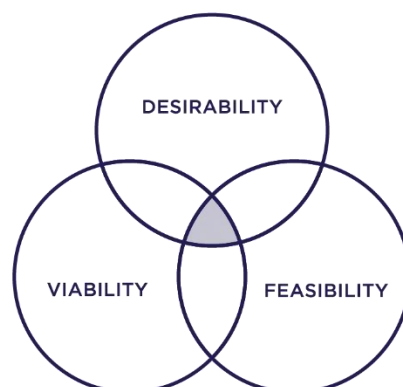
“Design thinking is a non-linear, iterative process that teams use to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. It is most useful to tackle ill-defined or unknown problems and involves five phases: Empathise, Define, Ideate, Prototype and Test.” (Interaction Design Foundation)

Design thinking brings together what is desirable from a human point of view with what is technologically feasible and economically viable.

Desirability: What makes sense to people and for people?

Feasibility: What is technically possible within the foreseeable future?

Viability: What is likely to become part of a sustainable business model



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Five phases of Design thinking

Design Thinking has five steps: empathizing, defining, ideating, prototyping, and testing.

1. Empathise

Or research of users' need. Getting to know your users' needs, challenges, perspectives, and goals is how the Design Thinking approach enables you and your team to effectively unlock new solutions and ideas that will reveal new opportunities. It may sound obvious, but many organizations forget that in order to effectively empathize, you need to actively observe user behavior and engage with real human beings! This real-life interaction will help you to internalize the user's experience of your company, products, service, and brand and understand your users' emotional and psychological responses to them. The empathy stage also involves putting aside personal assumptions and gathering insights. Taking into account the culture and context of the consumer will also be crucial.

2. Define

The definition stage is all about drilling down into what you've learned during your research in the empathy stage. Using the insights, you've gathered, you'll begin to have a much clearer idea of ongoing issues and possible solutions; you'll notice patterns and themes emerging. This stage is all about identifying the key needs to be addressed and articulating the main challenge or challenges for the workshop. Getting everybody on the same page at this early stage ensures that the goals of the problem-framing and problem-solving stages are clear and aligned.

3. Ideation

With the challenge articulated and the customer's point of view thoroughly understood, the ideation phase is when the collaboration and problem-solving really begins. Different techniques are often used in the ideation phase in order to bring about the best in the group and motivate different approaches. Brainstorming, mind-mapping, landscape mapping, bodystorming, lightning demos, and 4 step sketching are all brilliant and effective ways to prompt innovation and inspire the group to look at the problem from new angles. The key to a successful ideation session is to establish and nurture an environment within which every kind of option, approach, and opinion are accepted and rigorously assessed, with the ultimate objective being to converge on the strongest ideas which solve the issue at hand.





A simple assessment tool with which to approach potential solutions is a S.W.O.T. (strengths, weaknesses, opportunities, threats) assessment. This will also build confidence around the ideas that the group eventually decides to move forward with.

4. Prototyping

This is the experimental stage where the team gets to turn abstract ideas and theories into tangible experiences. Rapid iteration is crucial here, as solutions are put forward, improved upon, rejected, or restructured. This process forces the team to drop any ideas of perfectionism, promotes collaboration, and embraces mixing and matching ideas from different sources to come up with the right solution.

Some common types of prototyping in a Design Thinking workshop include: Sketches and diagrams Paper interface Storyboards Role-playing.

5. Testing

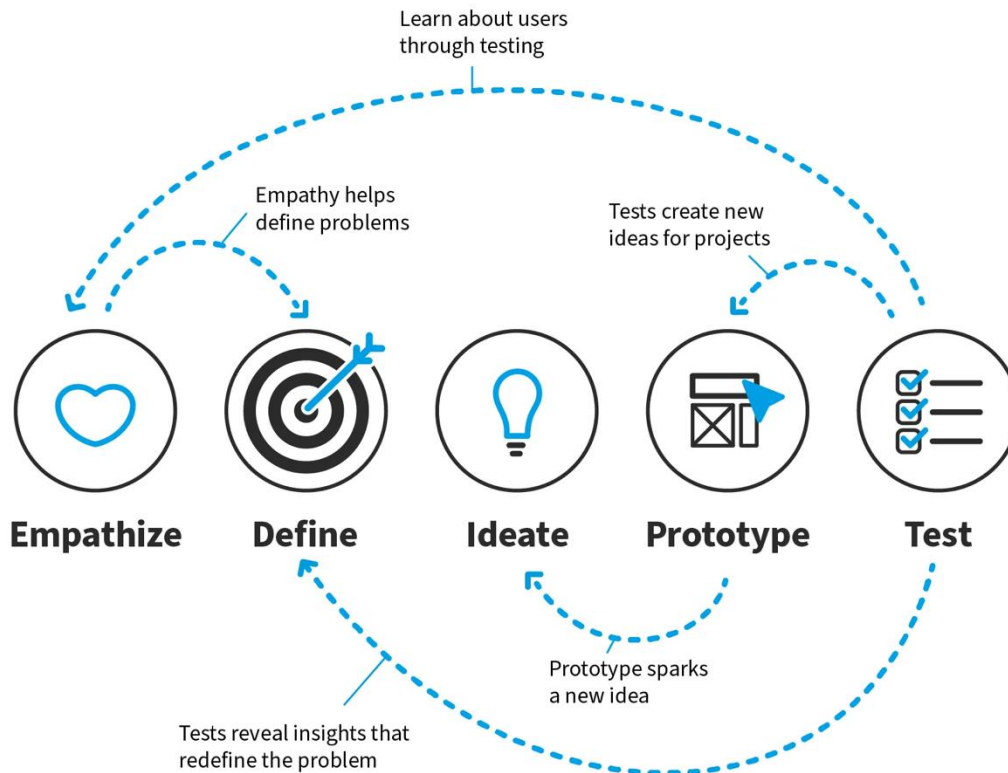
The value of testing to the Design Thinking process cannot be understated. It is perhaps even the most important stage in the workshop, as it enables the team to see if their solution effectively solves the user problem that was uncovered during the Empathy stage. Testing is your team's opportunity to get the product out into the real world and tested with real users, in real time. You'll be able to verify if the problem was framed correctly, and uncover new insights by observing users interacting with the product. It's also likely that you'll uncover new user needs and wants that were not previously articulated in other stages of the workshop.

Importantly, design thinking is not a linear approach, but a way to solve challenges iteratively, repeating necessary design thinking process phases until satisfactory results are achieved.





Design Thinking: a Non-Linear Process



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Resources

- What Is STEAM Education and Why Is It Important? (<https://cie.spacefoundation.org/what-is-steam-education-and-why-is-it-important/>)
- What is STEAM Education? (<https://www.arduino.cc/education/what-is-steam-education/>)
- What is the Role of a STEM Educator? (Project Lead the Way; <https://www.acpsd.net/site/handlers/filedownload.ashx?moduleinstanceid=26683&dataid=6591&FileName=What%20Is%20the%20Role%20of%20a%20STEM%20Educator.pdf>)
- STEAM (science, technology, engineering, arts and mathematics) (<https://www.techtarget.com/whatis/definition/STEAM-science-technology-engineering-arts-and-mathematics>)
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- Environmental sustainability synonymous with the future: 13 tips that will change your mindset (<https://joeducation.eu/environmental-sustainability-new-european-bauhaus/>)
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- 16 Public Speaking Tips for Students (<https://www.verywellmind.com/public-speaking-tips-3024732>)
- Planning a Makeathon (<https://makeathon.mtflabs.net/planning-a-makeathon/resources-and-materials>)



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