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State-of-the-Art report on Design Thinking and Maker Education

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Contents

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CHAPTER 1

Introduction

The 'DESIGN FUTURES' Project

The overarching goal of the DESIGN FUTURES project is to empower the students of today to contribute to the design of a better future. We believe that we can support the students' imagination, self-esteem, and making abilities by letting them experience **Design Thinking** and **Maker Education** activities at a young age. Therefore, we aim to create materials that support teachers with implementing Design Thinking and Maker Education practices in their school curricula. These pedagogies offer an interactive, open-ended, student-driven, multidisciplinary experience that enhances the development of diverse skills, knowledge, and ways of thinking.

The two main target groups of the project are **teachers (directly)** and **students of 10 to 14 years of age (indirectly)**. Through 'DESIGN FUTURES', we aim to support and strengthen the capabilities of teachers and educators to apply innovative practices related to Design Thinking and Maker Education in their teaching. In this way we hope to further enrich their educational practices and boost learning outcomes for their students. We envision that through the implementation of these practices in their teaching, educators will become able to support students to develop the skills, knowledge, and attitudes they need to actively engage with the world in their professional and personal futures. We, therefore, focus on engaging teachers, students, school-staff, parents, and policymakers in co-creating an ecosystem, in which students will be introduced to Design Thinking and Maker Education approaches from an early age. As a result, students will gain ***self-confidence*** through making, they will become better at ***collaboration*** and, also, develop new and ***creative*** ways of solving problems. Hence, through DESIGN FUTURES we aim to contribute to the development of students' 21st-century skills, such as creative thinking, problem-solving, teamwork, communication, and basic ICT competencies.

Shaping these skills and behaviors at an early age is important for students to later thrive in their everyday life as they allow them to become more self-confident and empowered to contribute to their communities through their knowledge and abilities. In order to succeed in harnessing these skills in students, the DESIGN FUTURES project will, through user-centered design methods, develop, test, and reflect upon a creative **Student Curriculum** that incorporates Design Thinking and Maker Education activities, a **Teacher Training package** that enables teachers to implement the activities in their curriculum, and an **Assessment methodology** that supports the teacher into tracking the students' learning outcomes and allows us to validate learning outcomes of the curriculum.

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An overview of this report

The main aim of this report is capturing and analyzing existing formal, informal, non-formal practices, which include a Design Thinking and/or a Maker Education approach within educational activities. In this way, the design of the DESIGN FUTURES training materials and curriculum will be updated according to the State-of-the-Art standard in the educational practices that exist at European and international levels.

In this output, we first explore and summarize theory and other related work on Design Thinking and Maker Education pedagogies. From this, we extract a workable definition of both which will be used to select contemporary practices that fit these definitions. These practices should also meet our other selection criteria which reflect the scope and aims of the project and will ensure that we analyze practices that are relevant to our envisioned outcome. When relevant practices are selected, we will analyze them through mapping them to van den Akker's curricular spiderweb (van den Akker, 2003). This spiderweb is a valuable way to visualize the different curriculum components. The mapping of these practices to the spiderweb will enable us to explore their main characteristics and the connections between them. Lastly, we will pinpoint some focal elements and reflect upon their implications for designing and developing the DESIGN FUTURES programme.

More specifically, this output is comprised of three interlinked sections. We start with the theoretical foundations around Design Thinking and Maker Education pedagogies in Section 2. There, we focus on eliciting information on what Design Thinking and Maker Education are, what they entail, and how they can be combined with each other, according to researchers and theorists that have worked on the subject. In addition to that, we highlight the opportunities that these two approaches offer towards cultivating students' competencies and further fostering the professional development of teachers and educators in general. This section concludes with the difficulties and barriers that, according to the literature review, exist with embedding such practices into lessons and curricula. We continue, in Section 3, with the analysis process in which twenty-eight (28) practices shall be examined, falling under specific selection criteria, as further described in the respective section. The practices will be sorted to whether they belong to a Design Thinking, Maker Education or combination approach and they will be mapped to the elements of the curricular spiderweb that we believed to be relevant. The results of this process will be demonstrated in text and summarized through three illustrative state-of-the-art design diagrams that showcase the current characteristics of each pedagogical approach. To conclude, in Section 4, we will discuss the results of this analysis by highlighting the underlying relations of the characteristics, connecting the insights of the analysis to educational theory, and reflecting on their implications for the design of the DESIGN FUTURES training materials and curriculum.

This output is fundamental, as it provides the foundational insights of the project. What is reported herein shall be taken into strong consideration when structuring the rest of the project intellectual outputs. More specifically, the findings of this report are imperative for the development of the project because they will feed into the design of the different

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DESIGN FUTURES teaching and support materials during the development of the student curriculum and the teachers training package. Also, this report's findings shall be further examined during the need's analysis with teachers and students, ensuring in this way that all target groups' needs are adequately addressed and that the characteristics of our training materials and curriculum will be based on their preferences. At the same time and for the materials to be usable for teachers, a flexible evaluation methodology shall be developed for equipping teachers with tools that would enable them to collect accurate and comparable data in relation to the learning outcomes achieved for both teachers and students.

Indicators of success

The DESIGN FUTURES project has been carefully designed both in terms of the partnership as well as the outputs that shall be developed. As such, it brings together an excellent consortium of experts in the Design Thinking and Maker Education fields, to produce quality training and teaching materials that will infuse young learners with the skills they need to thrive in the 21st century and to design better futures for themselves and others. The practical and hands-on experience of the partnership in Design Thinking and Maker Education is an asset for the successful implementation of the project outputs as well as for the design of a unique and thoughtful curriculum that could be embedded and replicated in different national and regional curricula around Europe.

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CHAPTER 2

Theoretical foundations

With the current rate of technological progress and changes in society, the future is now more unknowable and complex than ever before. To prepare children for this future, we need to develop in them skills that allow them to handle these uncertainties. Therefore, cultivating the so-called 21st century skills (Binkley, et al., 2010) in students and equipping them with skills such as critical thinking, empathy, creativity, innovative decision-making processes, and a collaborative mindset is essential. Today, solving problems and creating innovative ideas is a critical component of children's development and part of the desired progress within any community. In recent years, an interesting approach has grown in popularity, that of Design Thinking. This is a practice which can be used to educate not only children, teachers, but also managers or other professionals so that they become more proficient and creative in solving problems.

Schools and universities try to update their teaching methods so that they fit with the needs of society and their enterprises, therefore trying to prepare learners (of any educational level) for the future. As such, new techniques are being adopted by teaching communities in order to foster differing ways of thinking in a more collaborative environment. In this report, we will focus on practices aimed at children, trying to find techniques that can prepare them to become not only critical, creative thinkers, but also socially proactive, empowered, responsible and engaged citizens. This can be supported by **Design Thinking** activities as an important point of the Design Thinking process is that it not only produces anthropocentric products and services, but the process itself is highly focused on the values, reflections, and motivations of the designer (Friendman, 1996). And **Maker Education** practices have the possibility to raise students' capabilities to physicalize their concepts and build the necessary self-esteem regarding their ability to enact change within their environments.

Design Thinking

The Global Initiative Partnership for 21st Century Skills has acknowledged that new teaching styles have emerged in the past decade as a way to adapt to the needs of the new generation of learners. **Design thinking** is one of the most common concepts in this change. It was firstly applied in the business sector as a means to increase innovation and competitiveness. However, due to its human centered approach, it has been transferred and applied also to the education sector.

Design Thinking definitions

Design Thinking is about understanding human needs and motivations. It is a collaborative, experimental and iterative approach that requires teamwork and reflection. The focus is not only on solutions that are human centered, but the process itself is also deeply human. There are various other interpretations given by different theorists and researchers. For

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instance, Pattner et al. (2011) mention that Design Thinking is a human-centric methodology that combines or involves several academic disciplines, such as engineering, social sciences, and business, in order to produce innovative products, services, procedures, and solutions. Another definition is given by (Cross, 2011), who describes Design Thinking as a procedure that consists of the identification of a problem, analysis, and forming of the situation, searching for possible solutions, and generating several ideas, including innovative directions, such as creative thinking, modeling and sketching, prototyping, testing, and evaluating.

Design-based learning

In education there have been several approaches that apply the design thinking to the educational curriculum. For example, the *design-based learning* approach: an approach in which students learn by going through an iterative process to create design solutions (Scheltenaar, van der Poel, & Bekker, 2015), with the aim to foster creativity, teamwork and increase student's interest in learning. Design-based learning includes the students' collaborations, assessments and considerations during a design process, and the development of the appropriate teacher's and student's role (Bekker, Bakker, Douma, van der Poel, & Scheltenaar, 2015). As such, design-based learning fosters an innovative way of learning and solving problems. It provides an entirely different way of teaching in which students become co-owners or creators of a research/design assignment and, therefore, learn to think critically (Scheltenaar, van der Poel, & Bekker, 2015). At the same time, it allows teachers to combine the development of theoretical knowledge and 21st century skills and allows the students to immediately apply what they learn in a social context.

The Design Thinker

According to Brown and Wyatt (2010), the person who acts as a design thinker is characterized by:

- **Empathy**: They use their insights to offer solutions with a "people-first" approach.

- **Integrative thinking**: They have strong analytical skills and examine all the aspects of a situation and every scenario of possible outcomes.

- **Optimism**: They do not feel disappointed even though they might face challenges and failures.

- **Experimentalism:** They ask always questions and explore limitations with creativity.

- **Collaboration**: They have knowledge in more than one field.

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Design Thinking Processes

The Inspiration Space

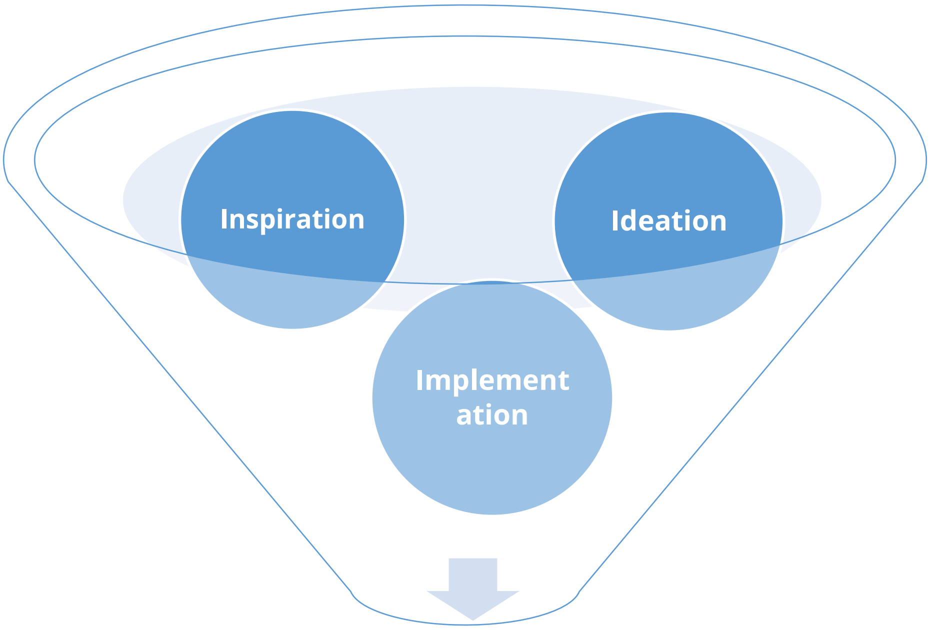

Figure 1. *the Design Thinking inspiration space, adapted from Brown and Wyatt (2010).*

To foster these attitudes in individuals, theorists have formulated different Design Thinking processes. Brown & Wyatt (2010) see Design Thinking as a system of overlapping spaces, rather than a linear process. In **Figure 1**, we tried to visualize the spaces that Brown & Wyatt include in their design thinking system.

According to them, the *inspiration space* refers to the orientation of a possible solution to a problem or a new opportunity, which can motivate people to search for solutions. It is the entry point that gives the project team a framework from which to begin. *Ideation* is the space of brainstorming, generation, development and testing of new ideas. And finally, the *implementation space* refers to turning those ideas generated during the previous spaces into a concrete and fully conceived action plan. It is important to mention that it is not a linear process but a process where different projects could undergo several feedback loops and iterations. A project can return to the initial space, for refining and updating the ideas expressed and exploring new directions. Complementing that, according to Dorst (2011),

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the process of design thinking offers specific and purposeful ways of reasoning, and it can interact with people and tactics on different levels and practices.

Stanford d.school Design Thinking phases

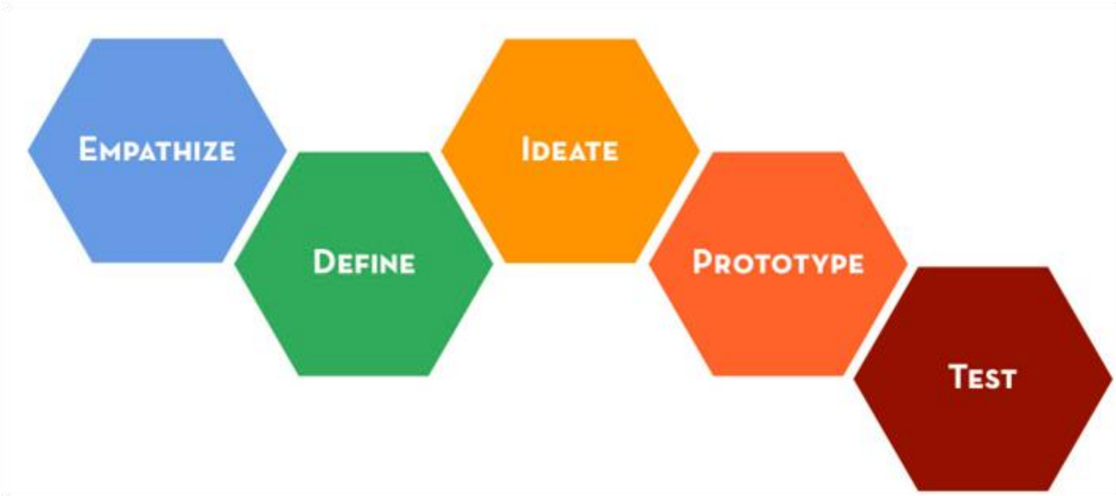

Figure 2. *Stanford d.school Design Thinking process*

Similar to Brown and Wyatt, the design department from Stanford University (d.school, 2010), define Design Thinking into 5 non-linear, iterative phases (see **Figure 2**). These phases are: Empathize, Define (the problem), Ideate, Prototype, and Test. This process which seeks to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test.

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Double Diamond process

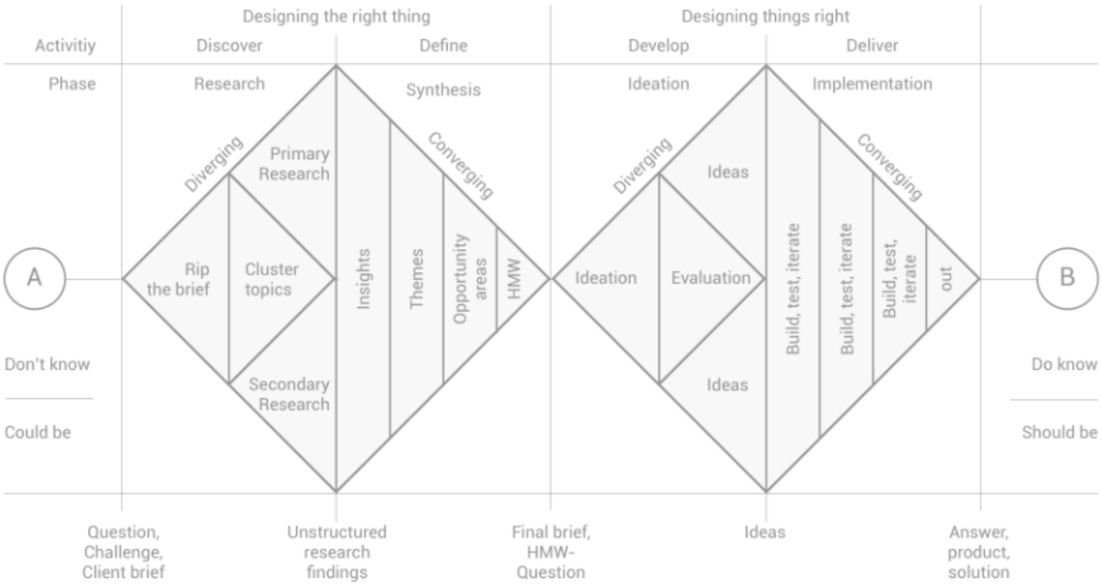

Figure 3. *the double diamond process of Nessler (2016).*

Other interpretations of Design Thinking see it as a more linear process. Such as the Design Thinking process that is presented by Nessler (2016): the ***double diamond process***, which takes a problem solver through two expanding and narrowing stages. Looking into the illustration of the diamond in **Figure 3**, the first diamond focuses on determining which problem needs to be solved (designing the right thing), asking the right questions, and the second diamond focuses on designing things right, making sure that you are on the right path. The difficult point is the transition from the first stage to the second stage, from how it could be to how it should be. In the first stage, there is the process of '*discovering/research*', where you look deep inside the problem, and the process of '*defining/synthesizing*', where you find where to focus. In the second stage, there is the process of '*developing/ideation*', where possible solutions are suggested, and the process of '*delivering/implementation',* where you come up with potential solutions which will be evaluated so as to be able to propose the final outcome.

Implementation of Design Thinking

Design Thinking can be practiced through activities in classrooms. Pierandrei and Marengoni (2017) conducted several activities in the educational contexts, working together with designers, teachers, educators and of course children. They differentiated three different activities in primary and secondary schools: design jams, workshops, and school projects.

In design jams, which were open to the audience, and design workshops, which took place in schools, children tried to transform their ideas into prototypes and experimented with these prototypes in a short amount of time. They developed their concepts through brainstorming. And through the process, children were encouraged to consider what others may think or need by placing their concepts inside an environment with multiple dimensions, actors, and points of view.

In the in-school projects, Design Thinking was applied in already existing didactic programs over a specific period of time. The process included the creation of concepts by the students through design methods, e.g. user journeys. The students learn how to work as a team that has specific goals.

Summary

Design thinking has been developed across engineers, business and management communities, and in the last years, it has become more popular in learning and educational settings. In education, design-based learning is gaining more and more space. Following a design-based learning approach, i.e. design thinking in education, has the potential to enable to students to design solutions to problems, boost their creativity and teach them how to collaborate in teams. As such, we work with Scheltenaar et al's (2015) definition of design-based learning, *a process in which students learn by going through an iterative process to create design solutions,* to identify educational practices that incorporate Design Thinking. In other words, in Design Thinking practices in which students try to solve a problem by iteratively creating concepts that they believe to solve the problem that they are tackling.

Maker Education

The Maker Movement

According to Martinez and Stager (2013), the Maker Movement is "*a technological and creative revolution around the world*". It started in America and since then it has been associated with many different terms, like "Hackerspaces", "Fab Labs" or "Maker Lab". Dale Doughtery was the one who inspired the Maker Movement in 2006 and since then, Davee et al. (2015) has mentioned 45 different making spaces with diverse activities, including digital technology, robotics, science, coding, prototyping tools, design, and art. The first idea was for people to work together using technology and new digital tools in order to find creative solutions to home problems (Dougherty, 2012). Through the surge of affordable digital fabrication tools, such as low-cost 3D-printers, laser cutters, and other CNC-based machines, and low costs electronics, the consumer became able to tinker and create with digital technologies. Empowering the general public and moving towards democratization of production. In general, the Maker Movement is based on creative production of artifacts, finding physical and digital ways to put someone's ideas into practice (Halverson & Sheridan, 2014).

Move to Education

Since then, Maker Education has been trying to apply the maker movement philosophy into education and create practical ways of learning (Riina, Anusca, & Yves, 2019). By combining elements of Constructivism (Piaget, 1964) and Constructionism (Harel & Papert, 1991),

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Cronin et al. (2018) highlight that "*Maker Education strives for the development of the individual through physical and social interaction with the world, often within the context of fabrication*".

During the last years, Maker Education is becoming more and more popular as an educational movement, applying "making" into classrooms aiming at developing students' creativity and problem solving skills (van der Poel, Douma, Scheltenaar, & Bekker, 2016) and allowing students to create artifacts that resemble desirable futures (Gershenfeld, 2005). Schools that support makerspaces are able to provide students with a framework where they can create and make things, while at the same time they learn new things and create new ideas. Thus, maker education programs are connected to and support learning.

Maker Education definitions

Dougherty (2012) describes the meaning of Maker Education as a human-oriented procedure where people are connected to each other and work together to make things happen. According to Hatch (2014), Maker Education involves the creation of a proper environment for the production of innovative artifacts, using the technologies of the 21st century. Halverson & Sheridan (2014) describe three main components of Maker Education: the *making process* (the set of activities), the *makerspaces* (a community with shared interests and idea), and *the maker as an identity*. In other words, Maker Education is an educational approach that connects students with other individuals, such as experts, users or enterprise, and environments to bolster pro-active attitudes.

It may include technological constructions utilizing new technologies of the 21st century, but also constructions, crafts, and prototypes without any technology. Maker Education tends to focus on interactive participation of and collaboration among students, their knowledge sharing, and a creative use of technology. In addition, Maker Education can aim at different aspects of education, such as supporting the main educational activities of the school with an inventive approach, but also social innovation, arts and culture, and developing digital skills (Riina, Anusca, & Yves, 2019).

9 core concepts

In his 'Maker Movement Manifesto', Hatch (2014) asserts that makers' activities are organized around nine key concepts. We have adapted these key ideas in an iterative model of the Maker Education process, illustrated in **Figure 4**.

Figure 4. *the 9 core concepts of Maker Education. Adapted from Hatch, 2014.*

According to Hatch' s manifesto:

- making is a fundamental human process of expressing ourselves,
- sharing our ideas with other people creates a sense of wholeness,
- giving is a step closer to connecting with other people,
- a lifelong learning path can lead to a rich and rewarding making everyday life,
- the right tools are needed to tool up our creatives,
- playing is necessary for an exciting making process,
- participating in making activities creates a strong community,
- supporting completes the emotional and intellectual frame of making,
- and the change will naturally occur through the journey of making.

The concepts of Maker Education as presented in Figure 4, according to Hatch's manifesto (2014), represent an inventive, motivated, and collaborative way of learning. It is useful to revisit each of these components on an iterative basis so as to enable the refinement and update of the solution that is being decided upon for solving a potential problem. In this way, optimizing in this way the concept that is being created.

Implementation of Maker Education

Maker Education can be seen both as a structured and non-structured way of learning. While employing Maker Education, learning can happen in differing ways and at various moments. Therefore, teachers should be supported in thinking more expansively about the 'who, what, and how' of learning of themselves and their students (Halverson & Sheridan, 2014).

Kolb (2014) categorized making in education as an experiential way of learning in which children learn through experimentation and reflection on knowledge and personal experiences, and not through experiences of others. This could be supported by a shift in the teachers' mental model of the students' learning, from learning solutions to increasingly

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harder exercises as an isolated set of skills towards seeing the students' learning as an integrated and connected framework across several projects (Halverson & Sheridan, The Maker Movement in Education, 2014). In other words, it is of importance to include the teachers' view on learning while designing for educational transformation.

Summary

The Maker Movement aimed to create a technical and creative revolution by giving more people access to new digital fabrication methods through fablabs and maker spaces. This philosophy influenced education and formed the Maker Education pedagogy. Maker Education has the potential to inspire many types of learning, but it is characterized by a student-centric, technology and making focused approach. It could influence and inspire teachers to run their classrooms more like a makerspace, where students can learn new skills through making. As stated in Halverson & Sheridan (2014), the direction of the Maker Education leads to progressive education fostering students' understanding on making artifacts that matter, creating thus a lever for learning in schools. In addition, making could have many educational benefits. It is suggested that through embedding Maker Education in formal education, students become more active problem-solvers while also becoming familiar with current technology and other scientific fields. This is because the students would interact with an integrated learning system and not an isolated set of skills and knowledge (West-Puckett, 2013).

From this, we define Maker Education as *a learning process that focuses on the production or fabrication of physical or digital artifacts that put the students' ideas into practice.* In other words, Maker Education practices are practices that focus on physicalizing an idea or concept of the students, focusing more on the learning of different making skills than fleshing out the concept or iteratively solving a problem

Combining Design Thinking and Maker Education

Design Thinking in education is a process in which students learn by going through an iterative process to create design solutions (Scheltenaar, van der Poel, & Bekker, 2015). Maker Education is aligned on making real applications and physical artifacts, often with the help of digital technology. The elements of these two educational approaches may be suitable to be combined. Both approaches are human-oriented and support the creation of creative and innovative ideas coming from a wide spectrum of learners (from students to adults). However, making is not always a part of a problem's solution, but it can take place for creating an application or an artifact (van der Poel, Douma, Scheltenaar, & Bekker, 2016).

A possible way for these two processes to work together is to start with a Design Thinking process to come to a concept and then continue with the construction of this concept supported by the core concepts of Maker Education.

Think, Make, Improve

Martinez and Stager (2013) describe a learning model that combines designing and making: Think, Make and Improve. Activities that could be included in the 'Think' phase are brainstorming, predicting, gathering materials, setting goals, sketching, deciding whom to work with, researching, planning. In the 'Make' phase of the process, students may: play, build, tinker, create, program, experiment, (de)construct, observe others, share and borrow code, document their process, ask questions and repair or modify their creation. Furthermore, in the 'Improve' phase, which is quite essential when learning, possible activities for students are: conduct research; talk it out; discuss with peers; use different materials and play with it. In relation to Papert's constructionist theory (1993), making and reflecting to make things better, leads to understanding. Hence, trying to balance between thinking, making and improving following an iterative reflection phase is (Martinez & Stager, 2013).

Research, Creation, Staging

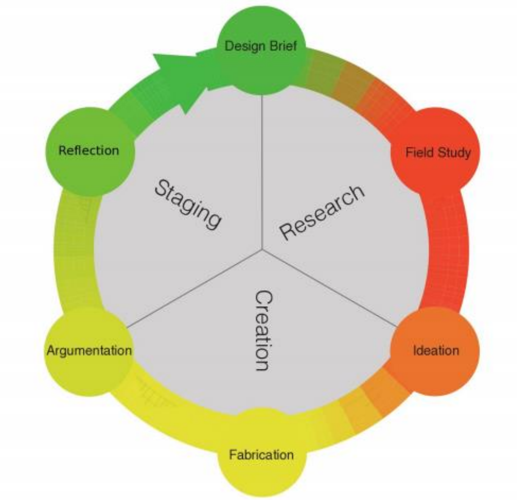

Figure 5. *The Fablab@school.dk process model for design thinking in digital fabrication (Smith, Iversen, & Hjorth, 2015)*

Smith, Iversen, and Hjorth (2015) highlight a designerly approach to digital fabrication in education: '*a hybrid learning environment that combines digital fabrication, design thinking and collaborative ideation and innovation to solve (complex) societal challenges.*' This definition stresses the entire creative process from early ideation, sketching, and mock-up creation to the initial presentation of a prototype, in which digital fabrication becomes a vehicle and resource for addressing personal or complex societal issues.

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Within their Fablab@School project, Smith, Iversen and Hjorth created a process model for their approach to digital fabrication in education. This model consists out of 6 steps in 3 phases (see **Figure 5**): Research, Creation, and Staging. The 6 steps include: Design Brief, Field Study, Ideation, Fabrication, Argumentation, and Reflection. They highlight the importance of framing and reframing the design brief, incorporate real world dilemma's in the design brief, integration of physical and digital materials, the development of a common language of design between teacher and students and between students, critical argumentation and reflection, and divergent and convergent thinking.

21st Century Skills

In the current education debate, much attention is paid to education of the future. The discussion focuses on the question of which knowledge and skills are important to prepare students for a rapidly changing society. Many of these skills are summarized under the heading of 21st century or cross-curricular skills. It concerns generic skills and the knowledge, insight and attitudes that are needed to function and contribute to future society. There seems to be broad agreement about the importance of paying attention to skills. To prepare students well for 21st-century society, it is considered important to give the skills a place in education.

Figure 6. *21 century skills as defined by SLO (Thijs, Fisser, & van der Hoeven, 2014).*

Combining the two concepts of Design Thinking and Maker Education in a learning process could be related to building competencies and capabilities. These two pedagogies could be a valuable resource for improving learning methods within schools that foster the development of students' 21st century skills. The 21st-century skills that are distinguished by SLO, the Dutch expertise centre for curriculum development, are *basic ICT skills*, *media literacy, information skills, computational thinking, creative thinking and acting, problem-solving thinking and acting, critical thinking, self-regulation, social and cultural skills, communication,* and *collaboration* (Thijs, Fisser, & van der Hoeven, 2014) (see **Figure 6**).

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Design Thinking can help students with developing *collaboration* and *critical thinking skills*, by for example trying to balance the interests of each stakeholder in a situation or a problem and trying to understand the consequences of each action on the system as a whole (Dunne & Martin, Design Thinking and How It Will Change Management Education: An Interview and Discussion, 2006). Moreover, according to Rauth et.al (2010), through the implementation of Design Thinking, students could develop innovative mindsets that can lead to the development of *creativity* and *problem-solving skills*. Furthermore, through the steps of the Design Thinking processes that have been discussed in the previous section, students develop soft skills, like *teamwork*, *critical thinking* and *empathy*.

Whereas through Maker Education, students could give students understanding of digital technology and *ICT basic skills* through digital fabrication. Digital creation, which could involve programming, could improve the student's *computational thinking* and *problem-solving* abilities. Furthermore, working together to build prototypes could improve *communication* and *collaboration* skills.

Summary

Through a combination of Design Thinking and Maker Education students learn how to act more independently and to take on new responsibilities. Design Thinking can help them generate creative ideas, and through Maker Education they can physicalize these ideas with real applications. Thus, when combining these two learning approaches, students have more flexibility in decision-making, and a strong basis for further development in the context of creative design.

Different models propose the combination of Design Thinking and Maker Education elements in the same process. For example, the Think, Make and Improve model of Martinex et al. or the model of FabLab@school.dk. Furthermore, a combination of Design Thinking and Maker Education might support the cultivation of various 21st century skills in students. From this, we define a practice that combines Design Thinking and Maker Education as a practice in which *students leverage technology, digital fabrication or construction tools to create design solutions that they came up with through an interactive process.*

Challenges when embedding Design Thinking and Maker Education in the curriculum

Design Thinking and Maker Education can offer significant chances in the curriculum and change the way students face a problem and generate new ideas and perspectives. However, integrating both approaches in the curriculum is still at a very early stage as curriculum development is an intricate process which involves many stakeholders and participants.

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Teacher Professional Development:

In order to adopt Design Thinking and Maker Education in the curriculum, teachers need to deeply understand how to create strategies for aligning a creative way of thinking inside their classrooms (Oliver, 2016a). Educators should be prepared for challenges that they are going to face while they are implementing Design Thinking and Maker Education inside the classrooms. They should develop both hard skills, like working with several materials and creating a variety of constructions and models, and soft skills, like searching for students' interests and supporting them to stay focused during the process even when difficulties arise (Oliver, 2016b).

When students participate in Design Thinking or Maker Education lessons, they want to be properly directed on the steps of these processes, as it might be something completely new for them, and quite different from the traditional way of teaching that they are used to. As a result, teachers should be well trained on the main steps of the process. For instance, they need to understand that during this process, students need to be able to identify a problem and be able to research on that to better understand the challenge that lays within it. Moreover, they should be able to produce prototypes on specific design plans, reflect on that and be able to receive feedback for improving the design which seeks to solve a problem. As a last step, they should be able to present and share those designs with others (Ajima, 2013; Yokana, 2014).

It is therefore important for educators to benefit from further professional development in developing these soft and hard skills, and the creation of Design Thinking and Maker Education projects in their classroom. Yokana (2014) recommends the adoption of a common direction for educators to implement design processes inside the classrooms. Educators must be supported in the creation of teaching materials with the resources they have at hand and the formulation of questions for the students that help them reflect on their process while keeping students' individual abilities in mind. In this way, the results of the implementation have more possibilities to be successful.

Learning processes that include Design Thinking and Maker Education would not be focused on what is "right" or "wrong" but would involve a process where teachers would focus on helping their students to think about the broader implications of their choices and decisions. Thus, teachers should give students opportunities to pursue their own independent interests with new skills (Oliver, 2016b). However, next to having to adapt to this new mode of teaching, educators gain more freedom to experiment with their teaching and can adapt a student-centered approach in their teaching to improve their students' learning experience (Krummeck, 2017).

Student Attitudes:

But change is not only needed on a teacher level, the attitude of the students' needs to change as well. From consuming the knowledge transferred to them from teachers and textbooks, the students have to become active agents that harness their own learning and see themselves as innovative thinkers. As a result, this implies that the curriculum will have to change in their overall orientation on the school or organization level (Plattner, Meinel &

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Leifer, 2011). Hopefully, leading to schools or organizations investing in professional development training for teachers that instill in them the knowledge, skills, and attitudes that are needed to become a facilitator of a Design Thinking and/or Maker Education process within their classroom.

Curriculum development:

Dunne and Martin (2017) further emphasized that the implementation of Design Thinking and Maker Education in the curriculum will lead to significant changes with far-reaching consequences. New competences and interests need to be harnessed by the students as Design Thinking requires students who can work on new and forward-looking processes with an open and modern mindset (Dunne & Martin, 2017). As a consequence, design educators face several problems with how to design a classroom curriculum that on one hand prepares students to effectively interact with Design Thinking methods as well as instill the competences and soft skills that are needed to interact with Design Thinking methods in their students (Cassim, 2013). Moreover, the assessment procedures of students need to be changed to reflect the versatile and open-ended nature of this new curriculum.

However, a different line of thought has been fostered by Zupan, Stritar, and Nabergoj (2005), who advocate that the implementation of Design Thinking and Maker Education as a course does not require changes in the core of the curriculum. They support that the techniques of design thinking can be applied to the currently designed courses, with the only difference that they will adopt additional tools and perspectives, which are able to improve the whole process. Therefore, they advise curriculum designers to understand in depth not only the course implementation but also the way students will interact with the implementation (Zupan, Stritar, & Nabergoj, 2005).

Curricular spiderweb

In order to overcome the challenges of implementing Design Thinking and Maker Education in the curriculum, we want to take an analytical approach to curriculum development. For this we decided to take the curricular spiderweb of van den Akker as the underlying model that guides the creation of our curriculum. This model will help us to get a grip of what the different components of the curriculum are and reflect on decision we make regarding each component.

According to van den Akker (2003), being consistent and creating balance among the different components that form a curriculum, is one of the main challenges for its development. Walker (1990) asserted that there are three main elements that need to be considered for when planning a curriculum. Those elements refer to its content, its overarching purpose, and the way the learning is organized. However, curriculum design and implementation has proven to be way too complicated and a more explicit attention needs to be paid to an extended list of components. Hence, a more elaborate list of components and levels was created by van den Akker (2003) in the curricular spiderweb (see **Figure 7**).

This spiderweb consists out of nine interlinked components that constitute a curriculum. Central to the spiderweb is the 'rationale' or the question 'why are the students learning?'. This serves as the orientation point. The nine other components, *Aims & Objectives, Content, Learning activities, Teacher role. Materials & Resources, Grouping, Location, Time, and Assessment*, are ideally linked to that rationale and preferably also consistent with each other. Curriculum designers are able to ask various questions related to each component. These questions can revolve around the purpose of learning, the content, ways to scaffold the learning, organizational structures or way to assess the aims of the learning.

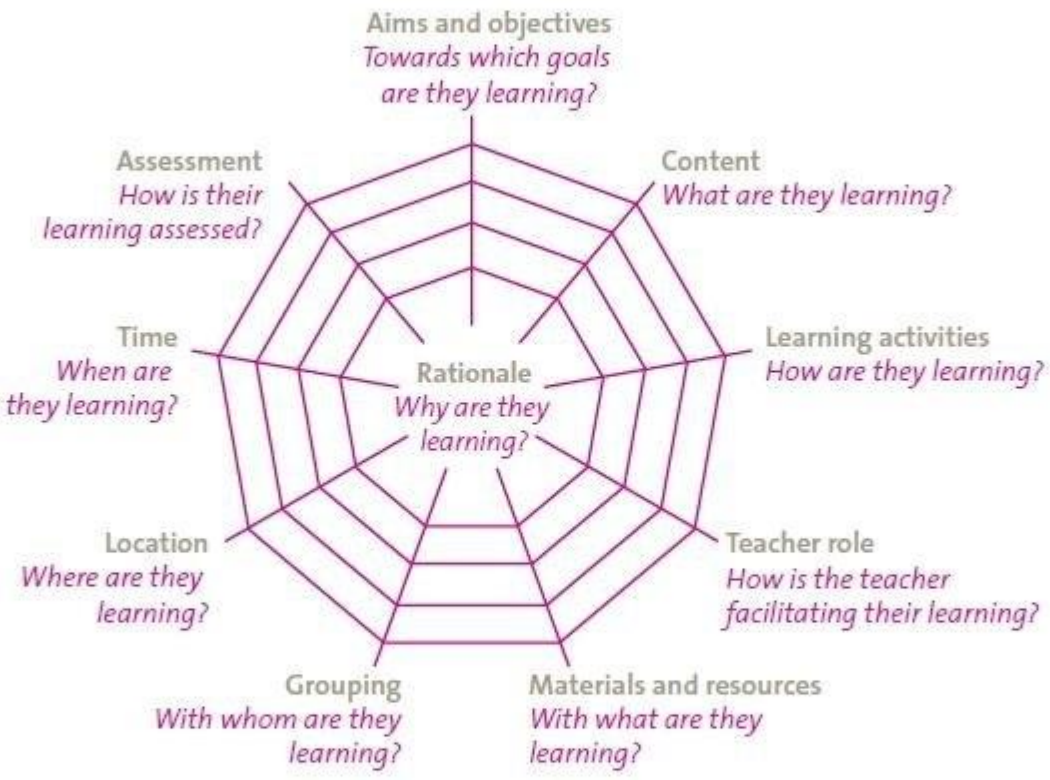

Figure 7. *The Curricular spiderweb by van den Akker (2003)*

Having explored the theoretical underpinnings of Design Thinking and Maker Education, it has been asserted that implementing and applying these two approaches, whereby a process that involves empathy, problem solving, and collaboration is followed. As such, it has the potential to cultivate creativity, harnesses self-confidence, and an innovative mindset. We believe it can better prepare students for the unknown future. Taking that into account, we need to overcome the challenges that arise when trying to implement these pedagogies into education. Such as supporting teachers from making the switch from an instructing role to a coaching role, cultivating motivated and curious mindsets in students, building a common language among students and teachers to be able to reflect together on their experiences within their new curriculum, and supporting teachers in making continuations or alterations on the curriculum. Therefore, we continue in the next section

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with analyzing practices that involve either Design Thinking, Maker Education or both by mapping them to the components of the curricular spiderweb. By doing this, we hope to get an overview of the characteristics of contemporary Design Thinking and Maker Education practice. By reflecting on these practices, we can inform our own design decisions that hope to mitigate or overcome the previously highlighted challenges.

CHAPTER 3: **Existing practices**

The aim of this section is to collect those approaches and techniques in Design Thinking and Maker Education that exist not only in the participating countries but at a European and global level and map them to the curricular spiderweb. The overarching aim for this analysis is to pinpoint the specific elements that characterize existing practices in such countries so as to be able to propose a cross cutting programme that would combine some of these elements, catering at the same time for the needs and preferences of our target group.

Selection criteria

Thus, for the selection of practices to be concise, the DESIGN FUTURES project team has agreed upon a set of criteria based on which the practices should be selected. These selection criteria are in line with the overarching goal of the project: supporting teachers with embedding Design Thinking and Maker Education in their curriculum in order to grow students' creativity, self-esteem, and collaboration skills. As we believe these skills will allow them to thrive in an uncertain future as active agents that create better futures for their communities.

The selection criteria are as follows:

- The practice should include Design Thinking, Maker Education or a combination of both as defined previously in this document.
- The information about the practice should describe it's learning activities.
- The students that are targeted by the practice fall into the age range of 10 to 14 years old.
- The practice should not be older than 2009.
- The practice should take place in a public environment, e.g. schools or fablabs. Practices that are targeted at the home should be excluded.
- The practice should include a teacher or facilitator.

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The selection process for our analysis comprised four steps: a general search, summarizing, summary screening, and specific search. 1) The general search was applied to the google search engine, google scholar, and the ACM Digital Library with a timescale from January 2019 to November 2019. Each project partner searched these databases to find practices from their own country, two project partners also focused on identifying practices from other countries. Eventually, 30 practices were selected. 2) Information about these practices were translated into English if necessary and summarized into data extraction tables (see Appendix A). 3) One researcher screened the summaries and selected practices based on the selection criteria. 18 out of 30 summarized practices remained. 4) One researcher screened the selected search databases again for practices that met the selection criteria, resulting into 10 extra practices.

Hence, this selection process resulted in a sample of **28 practices** that employ the design thinking and/or maker education approaches. Before describing them in detail, some of their characteristics are being summarized in **Table 1** below.

Table 1: *Summary of selected practices*

Practice/ Country	Ages	In brief
***GREECE*/** **Eduact**	5 to 15	Use Lego Mindstorms to create robots in an informal workshop.
***GREECE*/** **Eureka**	8 to 14	A design project that involves learning about inventors.
***GREECE*/** **Generation next**	4 to 18	Online platform with teaching material around STEM/Electronics and making projects.
***GREECE*/** **Future Designers**	10 to 15	A four-hour crash course that aims to introduce primary school children to the concepts and practice of creativity, design, and design thinking.
***ITALY*/** **Progetto SET - Scuola e Territorio**	12 to 14	An educational program that supports children in designing a new start up starting from an innovative product.
***ITALY*/** **Smart Future – Smart Coding/Smart Thinking**	6 to 18	The students collaborate on projects that require them to utilize computational thinking skills to redesign their school environments to better suit their needs.
***ITALY*/** **Dolomiti Digital Camp**	9 to 15	A workshop that teaches about new technologies, exploring creative potential and developing new capabilities of design, teamwork and management.
***ITALY*/** **Maker@Scuola**	4 to 18	A project in which students learn about 3D printers and biology.
***THE NETHERLANDS*/** **Designweek@school**	4 to 12	Organizes a design week at school with different labs in which students can experiment with different technologies.
***THE NETHERLANDS*/** **Designed by kids**	4 to 12	Lesson plans and design tools for each step of the design thinking process.
***THE NETHERLANDS*/** **My Machine**	4 to 12 (and	Machine building project: Elementary school children imagine a robot, higher education student make robot.

	higher education)	
***THE NETHERLANDS*/ Designathon**	7 to 12	A workshop of a day in which children go through a design process and physicalize their concept through basic electronics and rapid prototyping materials.
***ROMANIA*/ Design for change**	8 to 14	A design thinking project in the classroom. It aims to use design thinking to help children become creative, proactive, empathetic and responsible citizen.
***ROMANIA*/ Fondul Științescu**	6 to 19	The students learn scientific theoretical concepts in a practical experimental way. The goal is to make the students familiar with the latest technologies.
***ROMANIA*/ Makey Project**	6 to 12	Makerspace-type of workshops focusing on the idea of space exploration.
***ROMANIA*/ Impact Clubs initiative**	12 to 18	An afterschool club that does project with activities that have a social purpose and involve the community.
***ROMANIA*/ Kogaion Academy**	3 to 16	A summer school with an individualized program about technology and robotics.
***GERMANY*/ Playful Robotics Workshop (PlayRobs)**	7 to 12	Coding & programming robots workshop.
***USA*/ Tools at Schools**	12 to 18	School projects in which students work together with corporations to solve a problem in the community.
***SINGAPORE*/ Happiness Makers Workshops**	9 to 14	Design Thinking workshop.
***SPAIN*/ Activista I CAN**	12 to 13 & 15 to 16	Design Thinking workshop.
***USA*/ Taking Design Thinking to Schools Project**	12 to 18	Project focused on introducing students both to the design process and to systems in geography.
***PANEUROPEAN*/ NEMESIS**	4 to 18	Co-creation labs
***PHILIPPINES*/ Kids Can! Innovation camp**	4 to 12	Design Thinking workshop.
***USA*/ Agency by Design**	4 to 12	Design courses.
***USA*/ Dancing Robots**	4 to 12 (and higher education)	Machine building project: Elementary school children imagine a robot, higher education student make robot.
***FINLAND*/ CO4 LAB**	4 to 12	Making projects that involve IoT elements.

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Data Extraction and Analysis

The practices were being analyzed in terms of their **Pedagogical Approach**, **Formality**, **Aims and Objectives**, **Time**, **Content**, **Learning Activities**, **Facilitator Role**, **Materials and Resources**, **Assessment**, and **Social Relevance**. Pedagogical Approach refers to whether the practice incorporates the Design Thinking, Maker Education pedagogy or a combination of both. The factors; Context, Aims and Objectives, Time, Content & Activities, Learning Form, Facilitator Role, Materials and Resources, and Assessment are based upon aspects of the curricular spiderweb (van den Akker, 2003). Lastly, Social Relevance was included in the analysis as by interest of the project consortium. See Table 2 for more details.

Table 2: *Explanation of each factor of analysis*

Factor:	Explanation:
Pedagogical Approach	Does the practice incorporate Design Thinking, Maker Education or a combination of both?
Formality	Is the practice connected to the school curriculum or not?
Aims and Objectives	Towards which goals are the students learning?
Time	How long does it take to conduct the practice?
Content & Activities	Which learning activities are the students conducting and which 21st century skill(s) are they learning?
Learning Activities	How are the students learning?
Teacher/Facilitator role	How is the teacher/facilitator facilitating their learning?
Materials and resources	With what are they learning?
Assessment	How is their learning assessed?
Social Relevance	Is the practice connected to real world/societal issues?

Results:

As through our inclusion criteria, the pedagogical approaches of the practices consisted either out of **Design Thinking**, **Maker Education** or a **combination**. We coded practices as following a **Design Thinking** approach if *the students learn by going through an iterative process to create design solutions*. For example, the 'Designed by Kids' practice was coded as a Design Thinking practice because their materials are based on a process that is similar to Nessler's double diamond (Nessler, 2016) that the students used to create design solution. However, this practice didn't support the use of technology within their activities and is therefore not a combination practice. We coded practices as utilizing a **Maker Education** pedagogy if *the learning process was focused on the production or fabrication of physical or digital artifacts that put the students' ideas into practice.* Contrary to Design Thinking practices in which iteratively coming to a concept that solves a problem is central, the creation of the artifact takes the forefront in Maker Education practices. For example, in PlayBots the creation of robots is central to the practice. In which the aim of this creation is not that of

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solving a problem, but the act of making itself. Lastly, we coded practices as being a **combination** if *students leveraged technology, digital fabrication or construction tools to create design solutions that they came up with through an iterative process*. For example, Designathon utilizes a design process to support children in the design of a solution to a societal issue and they also provide students with electronic components and maker materials to create a higher fidelity prototype. This resulted in that out of 28 practices, 12 primarily leveraged Design Thinking, 8 were coded as utilizing a primarily Maker Education approach, and 8 practices combined both Design Thinking and Maker Education. **Table 3** shows the division of practices.

To provide information about the background of the 28 selected practices, we illustrate whether they are connected to the school curriculum or not (see **Table 3**). Of the 28 practices, 17 were connected to the school curriculum and thus coded as **formal**, whereas 11 were not connected to the school curriculum and coded as **non-formal**. More specifically, 8 out of 12 Design Thinking practices were coded as formal and 4 out of 12 as non-formal. For Maker Education practices, 3 out of 8 were coded as formal and 5 out of 8 as non-formal. For combination practices, 6 out of 8 were coded as formal and 2 out of 8 as non-formal.

Table 3. *Approach followed in each of 28 practices.*

Approach	N = 28	Sources	Formality
Design Thinking	12	Future Designers	Formal
		Designed by Kids	Formal
		My Machine	Non-Formal
		Design Thinking Toolkit	Formal
		Tools at Schools	Formal
		Happiness Makers Workshop	Formal
		Impact Clubs initiative	Non-Formal
		Taking Design Thinking to Schools Project	Formal
		Nemesis	Formal
		Activista I CAN	Non-Formal
		Dancing Robots	Formal
		KidsCan! Innovation camp	Non-Formal
Maker Education	8	Eduact	Non-Formal
		Generation Next	Non-Formal
		Maker@Scuola	Formal
		Makey Project	Non-Formal
		Fondul Științescu	Formal
		Kogaion Academy	Non-Formal
		PlayRobs	Non-Formal
		CO4 LAB	Formal
Design Thinking and Maker Education	8	Eureka	Formal
		Progetto SET - Scuola e Territorio	Formal
		Smart Future - Smart Coding/Smart Thinking	Formal
		Dolomiti Digital Camp	Non-Formal
		Designweek@school	Formal
		Designathon	Non-Formal
		Design for change	Formal
		Agency by Design	Formal

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In this section, we demonstrate the different qualities of the different analysis factors of the educational spiderweb and how they differ within each of the pedagogical approaches, Design Thinking, Maker Education or combination of both. We do this in order to find out which qualities are specific to each of the pedagogies.

Aims and Objectives:

To find the aims and objectives of the practices we analyzed their mission statement through inductive thematic analysis (Braun & Clarke, 2006). This revealed what it was that the designers of the practice wanted to achieve. A summary of this can be found in Table 4.

Table 4. *The aim and objective of each practice*

Approach	Aim/Objective	Practice
Design Thinking *(12)*	Creativity *(11)*	Future Designers
		Designed by Kids
		My Machine
		Design Thinking Toolkit
		Impact Club Initiative
		Tools at Schools
		Happiness Makers Workshops
		Activista I CAN
		Taking Design Thinking to Schools Project
		Nemesis
		KidsCan! Innovation camp
	Collaboration *(8)*	My Machine
		Design Thinking Toolkit
		Design for change
		Impact Club Initiative
		Tools at Schools
		Activista I CAN
		Nemesis
		Dancing Robots
	Empathy *(4)*	Designed by Kids
		Design Thinking Toolkit
		Nemesis
		KidsCan! Innovation camp
	(Social) Innovation *(4)*	Impact Club Initiative
		Tools at Schools
		Happiness Makers Workshops
		Nemesis
	Problem Solving *(2)*	Taking Design Thinking to Schools Project
		KidsCan! Innovation camp
	Social Awareness *(2)*	Impact Clubs Initiative
		Tools at Schools
	Doing *(1)*	Designed by kids
	Decision Making *(1)*	Designed by kids
	Meta-cognitive skills *(1)*	Design Thinking Toolkit
	Entrepreneurship *(1)*	Impact Clubs Initiative
	Critical Thinking *(1)*	Activista I CAN

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	Attitude towards Engineers *(1)*	Dancing Robots
	Self-esteem *(1)*	Happiness Makers Workshops
Maker Education *(8)*	Science/Technology Learning *(8)*	Eduact
		Generation Next
		Maker@Scuola
		Makey Project
		Fondul Științescu
		Kogaion Academy
		PlayRobs
		CO4 LAB
	Making *(5)*	Eduact
		Generation Next
		Maker@Scuola
		PlayRobs
		CO4 LAB
	Creativity *(2)*	Eduact
		Fondul Științescu
	Innovation *(2)*	Maker@Scuola
		Fondul Științescu
	Communication *(1)*	Makey Project
	Collaboration *(1)*	Fondul Științescu
	Problem-Solving *(1)*	Eduact
	Self-Esteem *(1)*	Eduact
	Playfulness *(1)*	PlayRobs
Combination *(8)*	Collaboration *(6)*	Eureka
		Progetto SET - Scuola e Territorio
		Smart Future - Smart Coding/Smart Thinking
		Dolomiti Digital Camp
		Designathon
		Design for change
	Creativity *(6)*	Eureka
		Progetto SET - Scuola e Territorio
		Smart Future - Smart Coding/Smart Thinking
		Dolomiti Digital Camp
		Designweek@school
		Designathon
	Communication *(4)*	Progetto SET - Scuola e Territorio
		Designathon
		Design for change
	Innovation *(3)*	Eureka
		Progetto SET - Scuola e Territorio
		Designweek@school
	Technology Learning *(3)*	Dolomiti Digital Camp
		Designweek@school
		Designathon
	Making *(2)*	Smart Future - Smart Coding/Smart Thinking
		Designathon
	Critical Thinking *(2)*	Designathon
		Design for change
	Entrepreneurship *(2)*	Eureka
		Progetto SET - Scuola e Territorio
	Computational Thinking *(1)*	Designweek@school

	Self-Reflection *(1)*	Designathon
	Ethics *(1)*	Designweek@school
	Empathy *(1)*	Design for change
	Project organization *(1)*	Design for change
	Leadership *(1)*	Design for change
	Empowerment *(1)*	Agency by Design
	Sensitivity to Design *(1)*	Agency by Design

Notably within the **Design Thinking** practices 11 out of 12 practices aimed for fostering more *creativity* in students. 8 out of 12 practices focus on supporting *collaboration*, 4 out of 12 focus on fostering *empathy* in students and 4 out of 12 aim to enable students to work on *innovation*, either social innovation or not. 2 out of 12 Design Thinking practices want to support students in their *problem solving* or *social awareness* skills. Other objectives that are found in 1 out of 12 practices are *doing*, *decision making*, *meta-cognitive skills*, *entrepreneurship*, *critical thinking*, fostering *positive attitudes towards engineering,* and increasing *self-esteem*. A practice can have multiple objectives, for example the Design Thinking toolkit by talent education aims to boost students' empathy, collaboration, creativity, and meta-cognitions. Whereas some only state one clear aim, such as Future Designers which wants to support the students' creativity. The only practice that didn't mention creativity in their mission statement is the Dancing Robots from University of California, they focus on collaboration and fostering a positive attitude towards engineers.

All 8 **Maker Education** practices described their aim to be *science or technology learning*. 5 out of 8 explicitly focused on fostering *making* skills in students. 2 out of 8 practices want to support the creation of *innovations* and 2 out of 8 was to aid the *creativity* of the students. Other objectives that are found in 1 out of 8 practices are boosting *communication*, *collaboration*, *problem-solving*, *self-esteem*, and *playfulness*. The most important goal for Maker Education seems to be science or technology learning. For example, the Kogaion Academy, a summer school program, has science and technology learning as their singular core aim.

We found that the **combination** practices, just like the design thinking practices, have a wide variety of aims. In the combination practices, 6 out of 8 want to stimulate *collaboration* and 6 out of 8 want to support *creativity*. 4 out of 8 focus on *communication*. 3 out of 8 on *innovation* or *technology learning*. 2 out of 8 either want to support *making*, *critical thinking* or *entrepreneurship*. Other objectives that are found in 1 out of 8 practices are *computational thinking*, *self-reflection*, *ethics*, *empathy*, *project organization*, *leadership*, *empowerment*, and *sensitivity to design*.

Content:

Learning content concerns all knowledge, skills and attitudes that are linked to the activities of the practice. Two coders independently analyzed the information on the practices and assessed which 21st century skills the students would be training through the activities within each practice. The 21st century skills framework that we used are the 21st century skills as defined by SLO (Thijs et al., 2014). These consist out of *communication*, *teamwork*, *creative thinking*, *computation thinking*, *ICT basic competencies*, *information skills*, *media literacy*, *critical thinking*, *problem solving, social and cultural competencies*, and *self-regulation*.

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Table 5. *21st century skills per approach*

Approach	21st Century Skills
Design Thinking *(12)*	Communication (12)
	Creative Thinking (12)
	Teamwork (11)
	Problem Solving (6)
	Social and Cultural Competencies (4)
	Self-regulation (2)
Maker Education *(8)*	Teamwork (7)
	Computational thinking (6)
	Communication (5)
	Creative Thinking (5)
	Problem solving (5)
	Information Skills (4)
	Basic ICT skills (1)
	Self-Regulation (1)
Combination *(8)*	Teamwork (8)
	Communication (8)
	Creative Thinking (8)

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	Problem solving (6)
	Computational Thinking (5)
	Information Skills (5)
	Media Literacy (3)
	Social and Cultural Skills (3)
	Self-Regulation (3) Critical Thinking (3)

All 12 **Design Thinking** practices included activities that leveraged students' creative thinking and communication skills. In 11 practices, students worked in teams which aims to boost their collaboration skills. 6 practices included a design brief in which students had to solve a problem. 4 pract\subsices included activities in which students had to use social and cultural competencies. For example, DesignathonWorks in which the students had to design from different perspectives or My Machine in which elementary school students have to work together with an engineer in training. Lastly, 2 practices relied on students to use their self-regulation skills, either through self-reflection or project management.

From the 8 **Maker Education** practices, 7 included teamwork, 6 included activities that required students to practice computational thinking skills through programming or robot building, and 5 included *communication skills* through several presentation activities. 5 practices included activities that aimed to boost students' *creative thinking* by coming up with ideas to build. 5 practices included activities in which students had to solve a problem. Through having students look up information about a subject online, 4 practices involved information skills. 1 practice, CO4 Lab, involved Basic ICT competencies as the students learn how to create Internet of Things artifacts. And another practice trains students' self-regulation through self-reflection.

Within the 8 **combination** practices, all leveraged *teamwork*, *communication* and *creative thinking* skills, 6 involved activities that required students to practice their *problem solving skills as the design brief involved a problem and 5 included activities in which the children had to program to create a device, training their computational thinking skills*. 5 practices had children look up information about a topic and implement it in their projects, leveraging students' information skills. 3 practices invited students to experience or work with new media, for example VR, boosting their media literacy. 3 practices involved activities in which students had to work with users, work with companies or people from their local community. This helps students increase their social and cultural skills. In three practices students were asked to self-reflect, plan their own project or track their project progress, which boosts their self-regulation. Lastly, three practices involved worksheets which helped students to evaluate their design solution, for example Dolomiti Digital Camp uses the Business Model Canvas, which boosts their critical thinking.

Taxonomy:

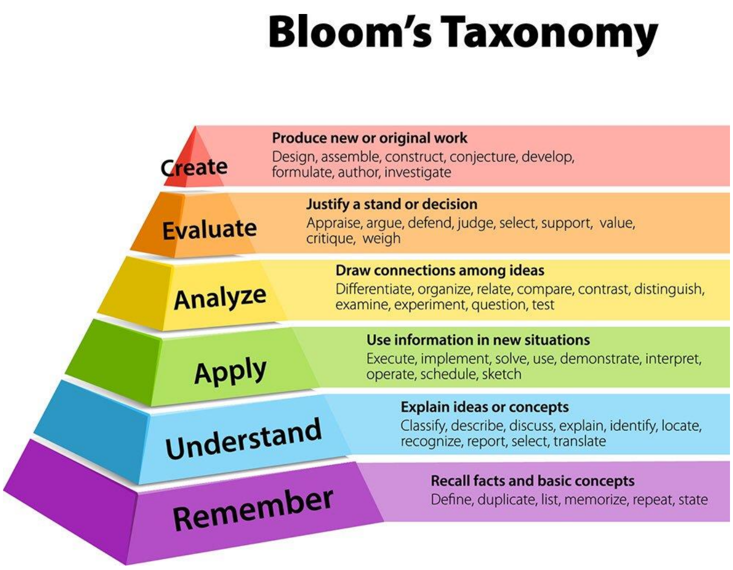

Figure 8: *Bloom's revised taxonomy by (Krathwohl & Anderson, 2009).*

We were also interested to which level of knowledge these activities would allow the students to go. We used the revised taxonomy of Bloom (Krathwohl & Anderson, 2009) as a lens to analyze the knowledge levels within the activities of the practice (see **Figure 8**). The revised taxonomy of bloom consists out of 6 levels: remember, understand, apply, analyze, evaluate, and create. The *remember* taxonomy level entails activities that aim to broaden a student's knowledge of a subject. Activities that are coded under the *understand* taxonomy level want the student to tap into their previously acquired knowledge and insights and describe, summarize or explain in this in their own words. *Apply* refers to activities in which students use previously acquired knowledge and insights in a new situation to solve a problem. The *analyze* level includes activities in which a student has to simplify a complicated problem to get a grip on it with their knowledge and insights. The students analyze it by, for example, creating sub-problems, reducing it to a pattern or an underlying problem, or concentrating on relevant aspects, such as important characteristics, causes or consequences. An activity in this taxonomy often requires critical and thorough (preliminary) research. Activities with the goal of *evaluation* students have to get to a substantiated judgment and position. The activity aims for students to justify a course of action, and to determine the value of something or someone. Lastly, activities in the *create* taxonomy level want students to leverage their knowledge and insights to create new ideas, products or visions.

Table 6. *Taxonomy level per approach*

Approach	Taxonomy Level
	Remember (6)

Design Thinking *(12)*	Understand (11)
	Apply (12)
	Analysis (3)
	Evaluate (3)
	Create (3)
Maker Education *(8)*	Remember (3)
	Understand (8)
	Apply (8)
Combination *(8)*	Remember (2)
	Understand (8)
	Apply (8)
	Analysis (2)
	Evaluate (2)
	Create (2)

In the **Design Thinking** practices, 6 out of 12 practices included activities which goal was for the students to *remember* new knowledge, 11 out of 12 practices aimed that students *understood* new knowledge, 12 out of 12 wanted students to *apply* knowledge in a new context, 3 out of 12 contained activities in the aim was for students to *analyze* a complex problem, *evaluate* the problem to come to a position and justify a course of action and leverage their knowledge to *create* new ideas, products or visions. A practice that has activities targeting all taxonomy levels is the American Tools at School practice. This is a 6 month long project in which students work together with a corporation to help students understand the value of design as a problem-solving tool in the everyday world. The practice incorporates activities in which they have to learn and remember the design thinking process and information about the problem that they are tackling. They do research to understand the problem. They apply this knowledge to the context they are working for and analyze the complex problem in this context through ideation methods. They evaluate their decisions through feedback from their corporate partner and finally create a high-fidelity prototype together with this industry partner.

Regarding the activities in the **Maker Education** practices, 3 out of 8 practices include activities aim for the students to *remember* new information, all practices want students to *understand* new information and *apply* this information to a new situation. No Maker Education practices include activities that have as goal for the students to *analyze* problems, *evaluate* options or *create* new artifacts.

The **combined practices** included 2 out of 8 activities that had as goal that students would remember new information. All practices included activities that aimed for students to understand new information and apply this information to a new context. And 2 out of 8 practices incorporated activities that had as goal that students *analyze* a complicated problem by drawing connections between ideas, *evaluate* the problem to justify decisions and *create* new or original work.

Learning Activities & Form:

Micro-level learning activities encompass the whole range of actions that students perform during the teaching-learning process. In the previous section we looked at the content, more specifically which 21st century skill the students were learning and to which taxonomy

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level. In this section we look at the activities in each practice and the overarching learning form that these activities were part of. Through inductive thematic analysis (Braun and Clarke, 2006), we coded the learning form that the activities were part of.

Table 7. *amount of and variety of learning activities per approach*

Approach	Learning Activity
Design Thinking (12)	Ideation (10)
	Mock-up creation (8)
	Design Challenge (3)
	Presentation (2)
	Sketching (2)
	Communication with engineer (2)
	Work with people from local community (2)
	Presentation (2)
	Field trip (2)
	Lecture on design
	Make poster
	Assessment
	Marshmallow challenge
	Reflection
	Work with organization
	Video making
Maker Education (8)	Programming (5)
	Robot building (4)
	3D printing (4)
	Workshop on new technologies (4)
	Ideation (3)
	Prototype creation (3)
	Work with Electronics (3)
	Research topic on internet (3)
	Design Challenge (3)
	Present (2)
	Online courses
	Video making
	Games
	Greenhouse study
	Poster creation
	Course
	Expert lecture
Combination (8)	Ideation (6)
	Mock-up creation (4)
	Research topic on internet (3)
	Prototype creation (3)
	Present (2)
	Design Challenge (2)
	Reflection (2)
	Work with people in local community (2)
	Project planning (2)
	Lecture on inventors
	Classroom Discussion
	Make poster

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	Collaboration with organization
	Workshop on new technologies
	Expert sessions
	Online courses
	Programming
	Electronics
	Field trip
	Video making
	3D printing
	Business evaluation

Ideation activities (n=10) are core to **Design Thinking** practices. Brainstorming or brainwriting are the most commonly used ideation activities. However, not every practice explicitly stated which methods they employed during ideation activities. This could mean that different methods could be employed or that ideation had more of a free form, in other words giving less boundaries to the children within the activity. Mock-up creation was used in 8 out of 12 Design Thinking practices. These are practices in which children create a proof-of-concept prototype of their ideas through basic materials, such as paper, cardboard, and tape. This allows them to reflect on the working of the concept and communicate the story of their concept to others. Other ways of explaining ideas to others that were used in Design Thinking practices were through creating a presentation (n=2), doing a poster presentation (n=1), sketching the concept (n=2) or creating an explanatory video (n=1). Students don't only need to explain their ideas to their team members, their peers or teacher, but in several practices, students also work together with people from outside their classroom or workshop space. In two practices, students work with individuals in their local community, in two elementary school students work together with engineers in training to create a robot, and in one practice the students work with a local organization that brings their concept to life. Moreover, when if the practice has the form of a design challenge (n=3) the student need to be able to present their idea to a jury that judges their concept. Other activities that are adopted in Design Thinking practices are the marshmallow challenge (cite) (n=1), introductory lectures on design (n=1), field trips (n=2), and self-reflection (n=1).

Most **Maker Education** practices involve activities that revolve around technologies, either through programming activities (n=5), robot building with robotics kits (n=4), 3D printing (n=4) or working with electronics (n=3). To teach these skills to students, practices pack learning activities in workshops on new technologies (n=4), expert lectures (n=1), online courses (n=1) or regular courses (n=1). In some cases, design challenges (n=3) are utilized as a vehicle for students to learn these new skills. Here, students can learn more about the topic of the design challenge by doing research on the internet (n=3), come up with new ideas through ideation activities (n=3), create a more technical prototype (n=3) through digital fabrication techniques, and present their work through presentations (n=2), creating a poster (n=1) or creating an explanatory video (n=1). Other practices include activities such as students playing educational games (n=1) or the investigation of processes within a greenhouse (n=1).

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The most common activities in **combination** practices are, just like Design Thinking practices, ideation activities (n=6). In these students think of new ideas through various methods to solve a design problem. This can be in the form of a design challenge (n=2), a project or a workshop. In some cases, the students work with individuals in the local community (n=2) or local organizations (n=1) to find a problem that they want to solve. Students create mock-ups (n=4) or higher fidelity prototypes (n=3). These prototypes can be made through 3D printing (n=1), programming (n=1) or electronics (n=1). Just as in Maker Education practices, these new skills can be learned through expert sessions (n=1), online courses (n=1) or workshops on new technologies (n=1). To evaluate their work, students self-reflect (n=1), discuss their project through a classroom discussion (n=1), or use worksheets, such as the business model canvas (n=1), to assess their work. To show their work, students can present their work (n=2), make a poster (n=1) or a video about their project (n=1). Because these practices often take more time than the practices than the practices of the other two approaches, it is required in some combination practices that students plan their project and track their progress (n=2). Other activities include an inspiration lecture on inventors (n=1) or a field trip (n=1).

Table 8. *Learning forms per approach*

Approach	Learning form
Design Thinking *(12)*	Project (6)
	Workshop (5)
	Challenge (3)
	Field trip (2)
	Course (1)
Maker Education *(8)*	Workshop (4)
	Project (3)
	Challenge (2)
	Course (1)
Combination *(8)*	Workshop (5)
	Project (3)
	Challenge (2)
	Course (1)
	Field Trip

These activities can be divided into macro-level learning forms, such as projects, workshops or courses (see Table 8).

The 12 **Design Thinking** practices included 6 projects, 5 workshops, 3 challenges, 2 field trips, 1 course. Some practices included multiple learning activities, for example the Dutch design thinking toolkit of talent education incorporates a project and a field trip.

The 8 **Maker Education** practices can be divided in 4 workshops, 3 projects, 2 challenges, and 1 course.

And the **combination** practices included 5 workshops, 3 projects, 2 competitions, 1 course, and 1 field trip.

Time:

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We analyzed the duration of each practice. To simplify this analysis, we divide the practices within four time intervals: a day or less, from a day to a week, from a week to a month, and more than a month.

Table 9. *Time span per approach.*

Approach	Time span
Design Thinking *(11/12)*	A day or less: 5
	From a day to a week: 1
	From a week to a month: 0
	More than a month: 4
Maker Education *(6/8)*	A day or less: 0
	From a day to a week: 2
	From a week to a month: 1
	More than a month: 3
Combination *(5/8)*	A day or less: 1
	From a day to a week: 2
	From a week to a month: 0
	More than a month: 2

For the **Design Thinking** practices we were able to find information about duration of the practice in 10 out of 12 practices. Of these 10 practices, 5 lasted a day or less, 1 lasted between a day and a week, no practices lasted between a week and a month, and 4 practices lasted more than a month.

6 out of 8 **Maker Education** practices included information about their duration. Out of these 6 practices none lasted a day or less, 2 lasted between a day and a week, 1 lasted between a week and a month, and 3 lasted more than a month.

Within the information of the **combination** practices we were able to find information on the duration of the practice of 5 out of 8 practices. One practice lasted a day or less, 2 between a day and a week, none between a week and a month and 2 lasted more than a month.

Teacher/Facilitator Role:

Teaching roles concern all roles that teachers (and support staff, guest teachers, etc.) play during the educational learning process to promote student learning. To define what these roles are and map them to the right activities, we discussed these roles with a Dutch secondary school teacher and educational researcher who is certified in teaching Research and Design (nl. *Onderzoeken en Ontwerpen*) and Engineering education (nl. *Techniek*).

From our discussion, the closed coding scheme resulted as follows:

- **Motivate**: Motivate student to perform task.
- **Diagnose**: Diagnose didactic problems or why a student is unsuccessful in completing a task, e.g. lack of background knowledge.
- **Explain**: Provide substantive explanations.
- **Instruct**: Give tasks to students before students start.

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- **Guide**: Supervising tasks during the learning activities.
- **Design and Research**: The teacher designs the learning activities or design brief.
- **Organize**: make contact with companies / experts outside school.
- **Assess**: assessing learning outcomes of students.
- **Give feedback**: Give feedback during the process.
- **Inspire**: interest / inspire in the subject.
- **Modeling**: the teacher shows how an activity should be done.
- **Reflect**: the teacher reflects on how they influenced the outcomes of the practice.

Together we mapped each activity within the practices to these roles. The few differences in opinions that arose were resolved through discussions.

Table 10. *The frequency of different teacher or facilitator roles per approach*

Approach	Facilitator role
Design Thinking (12)	Give Feedback (12)
	Inspire (12)
	Instruct (12)
	Guide (12)
	Motivate (10)
	Organize (6)
	Assess (4)
	Explain (2)
	Diagnose (1)
	Model (1)
Maker Education (8)	Instruct (8)
	Guide (8)
	Inspire (8)
	Diagnose (7)
	Motivate (6)
	Give Feedback (6)
	Explain (4)
	Model (4)
	Assess (3)
	Organize (2)
Combination (8)	Give Feedback (8)
	Inspire (8)
	Instruct (8)
	Guide (8)
	Motivate (7)
	Assess (4)
	Diagnose (4)
	Explain (3)
	Organize (3)
	Design & Research (2)
	Model (2)
	Reflect (1)

Through discussion, we believe that in all cases the teachers or facilitators role is to inspire students, instruct them on the tasks for every learning activity and guide them through the process of learning.

In formal learning practices, we believe that the role of the teacher is more to motivate, than in workshops which children might join on their own initiative. Which makes that in 10 out of 12 Design Thinking practices, 6 out of 8 Maker Education practices and 7 out of 8 combination practices, the teacher's role is to motivate the students. The core role for teachers in both Design Thinking and combination practices was giving feedback on the work of students. While in Maker Education practices this was part of the teacher's role in 6 out of 8 practices.

Some practices mentioned or explicitly described their assessment procedures, which would involve the assessment of students as a teacher role (n=4 for Design Thinking practices, n=3 for Maker Education, and n=4 for combination practice). One combination practice, Agency by Design, also includes material that aids the teacher to reflect on their teaching.

Many practices in collaboration with organizations, local communities or individuals. To host these practices, teachers have to organize connections with these groups: (n=6 for Design Thinking practices, n=2 for Maker Education practices, n=3 for combination practices).

The biggest difference in teacher roles between approaches lays in diagnosing a lack of background knowledge in students. In the design thinking practices this would be a task for the teacher 1 time out of the 12 practices. While in the Maker Education practices teachers would have to focus on diagnosing problem in 7 out of 8 practices, which is a stark difference. In the combination practices, teachers would have to focus on diagnosing learning gaps in 4 out of 8 practices. Moreover, because activities in Maker Education practices (n=4) are newer and more skill-based the teacher has to model learning activities more often than in Design Thinking (n=1) or combination (n=2) practices.

It is noteworthy that most practices don't use traditional methods of transferring knowledge, such as classical lectures. Because the learning happens more experiential, teachers give fewer substantial explanations (n=2 for Design Thinking practices, n=4 for Maker Education practices, and n=3 in combination practices).

Lastly, combination practices are sometimes open-ended. For example, Agency by Design, which presents a teacher with a bundle of learning activities and design methods. This allows teachers to design (n=2) a curriculum tailored to their needs and opportunities.

Materials:

Materials include all paper and digital materials that support an educational learning process. This can be teaching methods, teaching materials, manuals, tutorials or other sources, but also people (experts) who consult students and teachers during the learning process. Also consider the IT facilities that support the educational learning process, such as smartphones, tablets, computers and digital boards.

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Table 11. *Materials used per approach.*

Approach	Materials
Design Thinking *(12)*	Making materials (6)
	Brainstorm materials (4)
	Teacher guides (3)
	Student manual (2)
	Worksheets (1)
	Film equipment (1)
Maker Education *(8)*	Laptops + Software (5)
	Robotics kits (4)
	Making materials (4)
	Digital fabrication machines (2)
	Teacher guides (2)
	Greenhouse (1)
	Film equipment (1)
	Electronics (1)
	Video games (1)
Combination *(8)*	Templates/Worksheets (6)
	Digital fabrication machines (4)
	Teacher guides (4)
	Making materials (3)
	Laptops + Software (3)
	Robotics kits (1)
	Presentation equipment (1)
	Film equipment (1)
	VR (1)
	Assessment handout (1)
	Observation templates (1)
	Conversation starters (1)
	Reflection templates (1)
	Student manual (1)

The most frequent material used in **Design Thinking** practices (6 out of 12) were *making materials*. These are materials that were meant to rapidly physicalize ideas, such as pen, paper, scissors, tape, and other crafting materials. 4 out of 12 practices used *brainstorming templates*. 3 practices provided a *teacher guide* and 2 provided a *student manual*. The Design Thinking Toolkit used a team-based *worksheet*. Lastly, Activista I Can provides *instructional videos*. Most of these materials were meant to *assist in the learning activities*. More specifically, the student manuals and instructional video's help to *explain the learning goal* to the students. These can also be used by students to *track their progress*. The teacher guide helps the teacher to *implement the curriculum* and 2 out of 3 teacher guides had material provided assessment criteria that aided the teacher in *assessing* the students. Lastly, the worksheet that was provided by the Design Thinking Toolkit aimed to *support team structures*.

While the Design Thinking materials revolve mostly around pen and paper, the **Maker Education** materials are more technology oriented. In 5 out of 8 practices *laptops* and *specific software* are required. For example, Maker@Scuola requires the CAD software SugarCAD, a freeware software that supports 3D modelling in schools. 4 out of 8 practices use *robotics kits*, like Lego Mindstorms or Cubelets. 4 out of 8 practices require *making materials*, such as construction materials, like wood or specialized glue, or crafting

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materials, like paper, tape, and scissors. 2 practices also require *digital fabrication machines*, like 3D printers or laser cutters. 2 practices provide a *teacher guide* to help the teacher implement the curriculum and track the progress of the students. The Maker@Scuola practice includes a *greenhouse* which is used to teach students science principles. The Makey Project uses *video games* to develop students' digital skills and *film equipment* to develop the students' communication skills by presenting their work to facilitators and peers through video. Likewise, the Kogaion Academy requires *presentation equipment* so students can present their creation to facilitators and peers. Lastly, the Finnish CO4 Lab uses *basic electronic components* for the students to tinker with.

Combination practices make use of a range of materials. Most materials are used to *assist in learning activities*. For example, 6 out of 8 practices use *brainstorming templates* to assist the students in their ideation process. Other materials that help students with their process are the *reflection templates*, a *student manual* in which the topic and learning goals are explained and in which students can track their progress, and *conversation starters* provided by Project Zero's Agency by Design. 4 practices provide *teacher guides* to help teachers implement the curriculum, one of which included an *assessment handout*. In combination practices, also more technical tools are needed, 4 practices require the use of *digital fabrication machines*, such as 3D printers or laser cutters, 3 require students to use *laptops* with specific *software* such as 3D modeling or programming software and 3 practices require *making materials* in order to enable students to build prototypes. Designweek@School uses *virtual reality* to explain some of their topics. Dolomiti Digital Camp also requires *film and presentation equipment* so that the students can make videos about their concept to develop their communication skills.

Assessment and Evaluation

Assessment concerns the assessment and evaluation of the extent to which a student has achieved the learning objectives. We made a distinction between formative, summative, authentic, and ipsative assessment. *Formative assessments* (Black and Wiliam, 2009) occur during the learning process and are diagnostic in nature. As they are part of the educational learning process, they are usually intended to give students and teachers insight into the student's learning process and to provide customized education. *Summative assessment* (Harlen and James, 1997) is done at the end of the learning process around a subject. It is about measuring the final learning outcome by, for example, a test, a paper or presentation of the knowledge, skills and attitudes of students at a given moment. *Authentic assessment* (Wiggins, 1990) tends to focus on contextualized tasks, enabling students to demonstrate their competency in a more 'authentic' setting. They often use rubrics to attempt to make subjective measurements as objective, clear, consistent, and as defensible as possible by explicitly defining the criteria on which performance or achievement should be judged. In education, an *ipsative assessment* (McDermott et al.,1992) compares a learner's current performance with previous performance either in the same field through time or in comparison with other fields, resulting in a descriptor expressed in terms of their 'personal best'. It's a highly personalized form of assessment where progress is measured against the needs and goals of the individual, not in comparison to external standards or performance of peers.

Table 12. *Forms of assessment and assessment methods used per approach.*

Approach	Assessment Type	Assessment Method
Design Thinking *(2/12)*	Formative (1)	Competency assessment
	Ipsative (1)	Self-reflection
Maker Education *(2/8)*	Formative (2)	Observation grids
Combination *(2/8)*	Ipsative (2)	Self-reflection
	Formative (1)	Observation grids

Out of 12 **Design Thinking** practices, we found 2 practices that described their assessment procedures. Designed by kids utilizes a *formative* assessment method through assessing different competencies during different phases of the process. The Impact Club initiative uses an *ipsative* method by letting the students self-reflect on their learning outcomes.

Of the 8 **Maker Education** practices, 2 practice describes how they assess the students learning outcomes. Both the Maker@Scuola project and Kogaion Academy provide the teacher with observation grids to *formatively* assess the students during their process.

In the **combination** practices, we were able to find 2 practice that described their assessment procedures. Progetto SET - Scuola e Territorio utilized an *ipsative* self-assessment by having the students reflect on their process. Agency by Design by Project Zero include assessment methods for both student and teacher: it provides observation grids for the teacher to assess the process of the student, but it also provides self-reflection templates for both student and teacher. Therefore, it not only provides materials that enable *formative* and *ipsative* assessment. Moreover, it also asks the teacher to assess their own professional development.

While not always formally assessing the learning outcomes of the students. Some practices describe ways they have evaluated the practice itself. Specifically, 6 out of 12 selected **Design Thinking** practices describe how they evaluated the efficacy of their practice. Future Designers evaluated the ways in which the practice provoked the *creativity* of the students, the *engagement* of the students, and their *enjoyment* through observations and questionnaires. The design thinking toolkit let students evaluate how *challenging* they found the experience through questionnaires. Design for Change, Taking Design Thinking to Schools and Nemesis let the students evaluate their *experience* through questionnaires. Taking Design Thinking to Schools also evaluate the students' *exploration of the process* through observation. Lastly, Dancing Robots evaluates the students' *interest in engineering* and *attitude towards engineers* through post-questionnaires. For the **Maker Education** practices, 1 practice out of 8 evaluates their efficacy. The German PlayRobs evaluates the children's *experience* through a post-questionnaire. Within the **combination** practices we found 2 out of 8 practices evaluated their effectiveness. Design for change used post-questionnaires to evaluate the students' *creativity*, *empathy*, and *confidence*. Designathon uses more qualitative measures to learn about the *thoughts, worries, and learning outcomes* of the children.

Social Relevance:

Finally, we looked at whether the practices introduce students to real world or societal issues. For example, this could be done by linking the design or project brief of the practice was linked to one of the Sustainable Development Goals (SDGs) of the United Nations such as DesignathonWorks does or by involving the local community within the projects of students like for example the Impact Clubs Initiative.

Table 13. *Connection or possibility for connection to socially relevant topic per approach.*

Approach	Social Relevance
Design Thinking *(12)*	Yes (6)
	Possible (1)
	No (5)
Maker Education *(8)*	Yes (1)
	Possible (0)
	No (7)
Combination *(8)*	Yes (3)
	Possible (2)
	No (3)

In the **Design Thinking** practices, 6 practices included some link to a societally relevant issue. For example, the Nemesis project focuses on social innovation and enables students to create design solutions for problems in their social environment. 5 practices don't involve social issues. And 1 practice, designed by kids, has the potential to contain social issues by applying their method to a different project topic, but doesn't include social issues currently.

7 out of 8 **Maker Education** practices don't include learning about or tackling social relevant issues. However, Maker@Scuola involves learning about sustainability.

Within the **combination** practices, 3 practices contain learning about and designing for social issues, 3 don't, and 2 have the possibility to include social relevance in their practice.

Summary:

We selected and analyzed 28 practices that incorporated Design Thinking and/or Maker Education activities that targeted children 10 to 14 years old. We analyzed these practices according to the curricular spiderweb (van den Akker, 2003) and its underlying theories (Krathwohl and Anderson, 2009) in order to find qualities that are fundamental to Design Thinking and Maker Education and to lay bare the connections between these qualities and their real-world context. To summarize our results, we created three diagrams that show the most frequently found characteristics for each component of the curricular spiderweb that we selected for this analysis (see **Figure 9, 10** and **11**).

Design Thinking:

We analyzed twelve Design Thinking practices for children aged 10 to 14 in terms of their *aims and objectives*, *content*, *learning activities*, *the teacher's role*, *materials and resources*, *time*, and *assessment method*.

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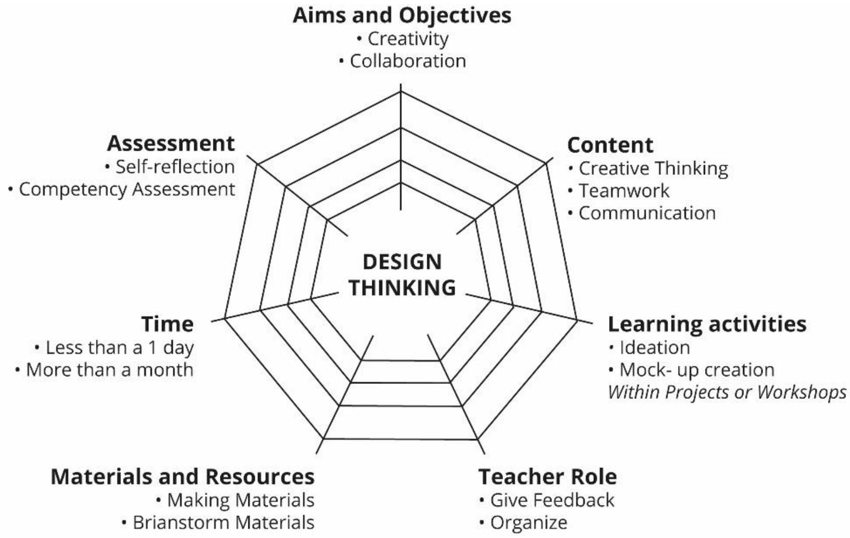

Figure 9. *diagram that shows the most frequent found characteristics in the analyzed Design Thinking practices.*

We found that most of these practices aim to boost creativity and collaboration in young children. Their content consists out of activities that boost teamwork, creative thinking, and communication. This content is packed in learning activities such as ideation activities or mockup creation in either long-term project or short-term workshops. The teacher's main role is to give feedback on the student's work and organize contacts with outside experts or organizations. The materials that are most often used are making materials for construction of low fidelity prototypes and brainstorm materials that help with ideation processes. The design thinking practices lasted either less than a day or more than a month. Assessment was done through either self-reflection or competency assessment.

Maker Education:

We analyzed eight Maker Education practices for children aged 10 to 14 in terms of their *aims and objectives*, *content*, *learning activities*, *the teacher's role*, *materials and resources*, *time*, and *assessment method*.

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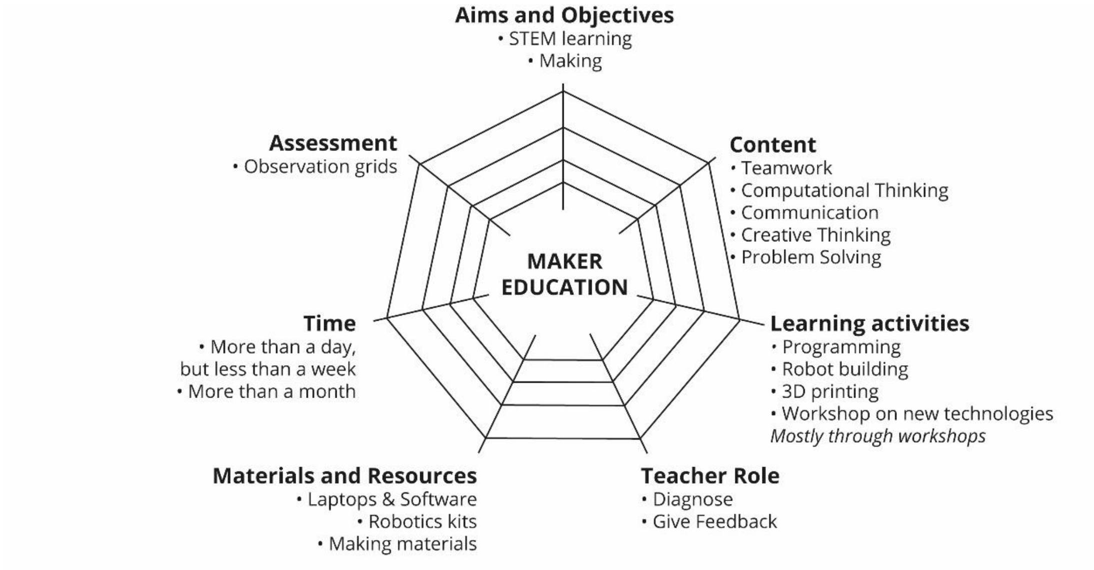

Figure 10. *diagram that shows the most frequent found characteristics in the analyzed Maker Education practices.*

We found that most of these practices aimed to promote STEM learning and making. Their content consists out of activities that support teamwork, computational thinking, communication, creative thinking, and problem solving. Examples of these activities are programming, robot building, 3D printing or workshops on new technologies. Most of these activities are part of workshops. The teacher role is mainly to diagnose didactical problems, such as missing knowledge that is required for the students to be able to conduct a task and give feedback on the students' process and ideas. The materials that are most frequently used in these Maker Education practices are laptops and particular software, robotics kits, and making materials. The practices mostly last more than a day but less than a week, or more than a month. And lastly, assessment is mostly done through observation grids.

Combination practices:

We analyzed eight practices that combined Design Thinking and Maker Education for children aged 10 to 14 in terms of their *aims and objectives*, *content*, *learning activities*, *the teacher's role*, *materials and resources*, *time*, and *assessment method*.

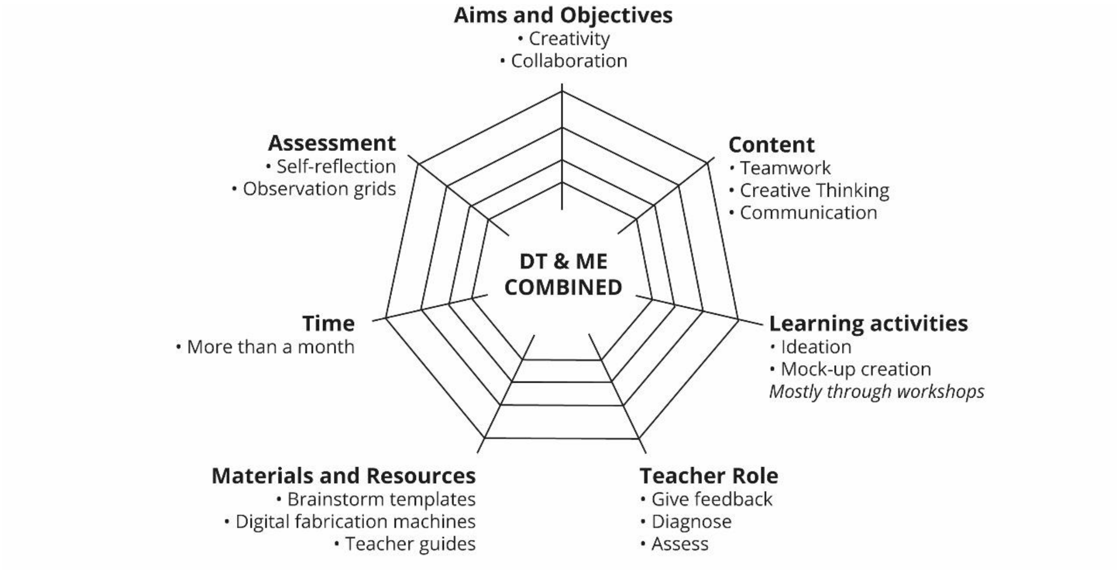

Figure 11. *diagram that shows the most frequent found characteristics in the analyzed combination practices.*

We found that most of these practices aimed to support creativity and collaboration. Their content consists out of activities that help to develop teamwork, creative thinking, and communication skills. Examples of these activities are ideation activities, such as brainstorming, or mock-up creation. These activities are mostly part of workshops. The teacher role is mainly to give students feedback on their concepts, diagnose missing knowledge and assess the students' learning. The materials that are most frequently used in these combination practices are brainstorm templates, digital fabrication machines, and teacher guides. The practices mostly last more than a month. And lastly, assessment is done through self-reflection or observation grids.

Differences between Design Thinking, Maker Education and Combination practices:

If we put the three diagrams in **Figure 9, 10** and **11** next to each other we can see that the current Design Thinking, Maker Education and Combination practices differ in terms of their qualities.

Where Design Thinking and Combination practices largely aim to support the development of creativity and collaboration skills in students, Maker Education aims to support Science or Technology learning and increase the students' making skills. We can see this in the activities that the practices include. All practices include activities that require teamwork and communication skills. But Design Thinking and Combination practices include more activities that necessitate students to leverage their creative thinking skills, like ideation activities. Whereas Maker Education practices focus on activities where problem solving skills play a key role, for example solving science or engineering problems that are predefined by teachers such as the creation of a sustainable greenhouse or activities that inherently require problem solving skills such as programming and working with electronics.

The learning activities of all practices are mostly included in either projects or workshops. These workshops either last less than a day, like in Design Thinking practices or a couple of days in

Maker Education practices. All projects last more than a month. Most strikingly, most combination practices are in project form and last more than a month. While students can go through one design thinking iteration through a workshop of a day or create a physical or digital artifact in a couple of days, going through the process of ideation and creation sequentially seems to be a process that requires more time.

In Design Thinking practices, the teacher's or facilitator's role involves mainly the task of giving the student's feedback on their concepts and mock-ups, while in Maker Education practices the teacher is meant to instruct the students on how to use the tools that they will use for the creation of their prototypes. In combination practices, the teacher's role involves both tasks.

Another big difference can be seen in the materials that are mainly used in the three approaches: Design Thinking practices mostly use making materials such as pen, paper, tape, and brainstorm materials such as post-its and pens to support their process. Maker Education also uses making materials, however these making materials more heavily rely on resemble sturdier construction materials such as cardboard, wood and glue. They furthermore rely more on electronic devices, such as laptops and robotics kits. Combination practices aim to streamline the brainstorm process by providing students with brainstorm templates. They also include digital fabrication machines, such as 3D printers and laser cutters, more often than purely Maker Education practices. And they frequently facilitate the teachers with teacher guides. This may be because combination practices require teachers to be knowledgeable about both the design thinking process and technology.

Lastly, a big difference lays in the assessment procedures in Design Thinking and Maker Education practices. While we were only able to find few practices (6 out of 28) that describe their assessment methods, we see that Design Thinking practices included more student centric methods such as self-reflection or competency assessment. In Maker Education all agency is put in the hands of the teacher through observation grids. We found that in combination practices, both self-reflection and observation grids were used. A noteworthy finding however is that in one practice self-reflection templates for the teacher were provided as well. Therefore, stimulating the teacher's professional development.

To conclude, Design Thinking and Maker Education are different in some fundamental ways. Where Design Thinking is a more open process where imagination can run wild, Maker Education uses materials that are bound to the physical world which in turn gives it a concrete set of boundaries. While this seems limiting, these boundaries might help novice design thinkers to get a grip on the process. In other words, the right and wrong nature of some of the Maker Education tools might scaffold the students' learning when conducting Design Thinking activities. In the next chapter, we will discuss further implications of our results and give some possible scenarios for moving forward within the project.

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CHAPTER 4
Discussion

In the previous chapter we showcased the results of the analysis of 28 practices that incorporated Design Thinking and/or Maker Education activities for children 10 to 14 years old. We found qualities that we believe to be fundamental to Design Thinking and Maker Education and thus we were able to demonstrate the differences for each approach according to the categories of the curricular spiderweb (van den Akker, 2003). In this section, we will discuss the further implications of our results reflecting on the internal connections of these qualities and we will give some possible scenarios for moving forward within the DESIGN FUTURES project.

Combining Design Thinking and Maker Education

Our analysis reveals that most current practices that combine Design Thinking and Maker Education commonly follow a process that starts with Design Thinking activities in which students iteratively come to a design solution to a real-world problem and subsequently make use of Maker activities in which the students construct a prototype that represents their solution. However, the focus in these practices is for the students to solve a real-world problem through these artifacts. The primary aim is therefore not to learn new making skills or gain an understanding of digital fabrication technologies, but to gain a more profound understanding of self in relation to society.

How can new technologies become creative materials for novices?

As mentioned in the previous chapter Design Thinking and Maker Education have fundamental differences that must be considered when trying to combine both pedagogical approaches. Where Design Thinking allows for expression of ideas and is only limited by language and imagination, Maker Education's root in the physical objects and physics creates many more natural boundaries. These natural boundaries are not only limited to the limits of physics, but also the tools that are presented to the students and their skills of molding these materials to fit their ideas.

Some practices try to overcome this skill gap by teaching these skills at the beginning of the process before advancing to Design Thinking activities. While this allows for a smoother transition from Design Think to making activities, this might bias the students' ideation activities towards ideas that incorporate the skills they have just learned. Which might limit the scope of thought as not all design solutions require a physical artifact. When starting with Design Thinking activities, students create a concrete concept to bring to life. Having a concrete concept that students wish to physicalize has the potential to motivate them to

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learn new skills that they would help them to create their concept. However, students might employ a means-to-an-end approach to using the skills and techniques that they learn in order to physicalize their concept. In turn, not fully grasping the right approaches or just learning shreds of a certain skill. Collaboration could minimize this. Collaboration between students allows for peer learning, but also collaboration with experts could help students to see the opportunities that technologies can provide.

Curriculum designers need to consider how and when they support the learning of the novices in a way that they can use new technologies as creative materials. Depending on the focus of curriculum, either a focus on creativity and soft-skills like divergent thinking or a focus on hard skills that are necessary for the creation with (digital) materials, the designer has to keep the sequencing of Design Thinking or Maker Education activities in mind and make choices on the process of their curriculum.

How can we support reflection and scaffolding?

From the practices we analyzed we saw that some specified their sequencing of activities through a process model. For example, DesignathonWorks has a worksheet that is comprised out of different activities in a sequence. Agency by Design also incorporated a worksheet that they called the 'Inquiry circle tool'. This tool aimed to make the students learning visible. The Inquiry Circle visualizes the design process and students can put a marker on the phase of the process they are currently working within. And as described in section 2, other practices have formulated process models for how to combine of Design Thinking and Maker Education.

Create a common language

A process model might help students with gaining a process understanding. This is sense of process might be a starting point for the students to develop a feeling for the design process and subsequently the development of language. To collaborate students, need to develop a shared language. A process model might guide and scaffold the creation of a design language amongst students. Moreover, the other tools and materials that are used within the process activities will also aid in the creation of a common language about design.

Support Reflection

The creation of a process model might also allow for and guide reflective thinking. We have to note that we focus our work on young children who will often be novices to the practices of Design Thinking and Maker Education. Reflection and evaluation will not come natural to these youngsters and some will even argue that they don't have the necessary mental models of the world or cognitive functions to truly reflect on how their decisions impact their environments.

While these processes may not come natural to the students, some resources might help students to look more critically at their decisions and reasoning for these decisions. A process model might give students a sense of direction in the chaotic process that is design.

For example, Agency by Design's Inquiry Circle, which visualizes the design process, makes the move from one phase to another a conscious process for the students as they have to physically have to move a marker from one part of the process to another. This might prompt questions like '*Did we take everything into account to move to the next phase? Are we missing something? What are we going to do next? Does everyone agree that we are moving on?*'. Tools like these can make reflection loops shorter and collaborative. Thus, if we students to reflect on their decisions and experiences, we need to provide the appropriate tools so that they, as novice reflective practitioners, are able to practice this meta-cognitive skill.

Scaffold learning activities

A process model would not only allow students to create a common language and reflect on their process, but it could also help as a guide for designers and teachers to create or choose learning activities for each of the process phase. Combined with Bloom's taxonomy, a process model could serve as a framework for curriculum designers to create activities with different level of abstraction. This could scaffold (Berk and Winsler, 1995) the learning of students. A way this framework could look like is illustrated in **Table 13**. The columns resemble Bloom's taxonomy. For the rows, FabLab@school.dk's process model is used as an example. The cells can be filled with design activities that the students can conduct.

Table 13. *Scaffolding framework that allows teacher to sequence learning activities. In the left column, FabLab@school.dk's process model and on the top row Bloom's revised taxonomy (Krathwohl and Anderson, 2009).*

	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Briefing		Mindmap		Stakeholders Scenario		
Field study				Observations		Interviews
Ideation		Sketching	Brainstorm	6-8-5	Criteria	
Fabrication			Mock-up			3D print Electronics
Argumentation				Network Pain-gain SWOT	Check Criteria	Usertest Presentation
Reflection						Manifesto

Learning is a gradual process in which new knowledge gets added on top of previous knowledge through reflections on experience. Most practices that we analyzed existed out of one project or one workshop. The students learned new skills within this project or workshop that they could apply in other situations. However, these practices didn't consist out of consecutive activities that would allow students to practice and build on top of their skills, like in for example a math curriculum. A framework that combines a learning level

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taxonomy together with a process model might help designers and educators to create a Design Thinking and Maker Education curriculum that scaffolds the students' learning over a longer period of time. However, we note that a framework like this should be seen as a conceptual toolbox from which you take concepts that you find useful and continue developing them further.

How can we align the different aspects of the curriculum?

Constructivist philosophy states that learners learn through their experience with the world. Therefore, it is important to link new materials to concepts and experience in a learner's memory and for them to reflect on possible future scenarios. To be able to give a consistent curriculum that is linked to a student's understanding and memory, we need to balance each component of the curriculum and align them. Therefore, making a deliberate alignment between the planned learning activities, the learning outcomes, and the way these learning outcomes are assessed. In other words, we need to provide the learner with a clearly specified goal through a well-designed learning activity, and well-designed assessment criteria for giving feedback to the learner.

A theory that can help us is constructive alignment (Biggs, 1996). The principle of constructive alignment states that testing and learning activities in education must be focused on the learning outcomes (see **Figure 12**). According to the principle, the design and development of education takes place in a certain order. First you set the learning objectives, then you design the assessment, then you consider which learning activities are needed to achieve the intended final level and finally you design the educational materials and your educational activities.

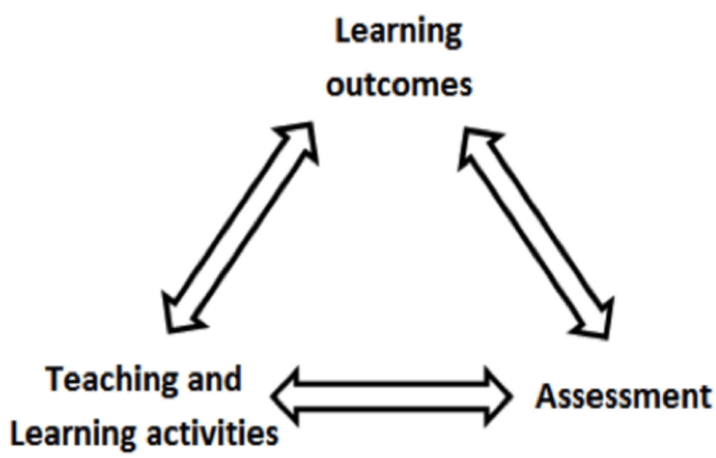

Figure 12. *Constructive alignment theory by Biggs (1996).*

Learning Outcomes

To be able to use this theory, we need to set clear goals on which goals we want to achieve without curriculum. Generalities do not imply any particular design decisions. Which makes it harder to align learning activities and assessment activities. It leaves the door open for external factors, such as student numbers or administrative convenience, to dictate teaching and assessment methods. The use of a taxonomy framework such as Bloom's taxonomy (Krathwohl and Anderson, 2009) allows us to rationalize what kind of understand we might mean in a particular case.

The combination of Design Thinking and Maker Education over a longer time period allows for more levels of learning to be supported. These pedagogies contain activities that can span all levels of the revised Bloom taxonomy of learning levels. However, our results show that the activities within Maker Education practices tend to have more fundamental learning levels than Design Thinking or combination practices. This might be because the activities within Maker Education focus more on skill learning which takes a longer period to master.

Through a framework such as illustrated in **table 13**, we can decide to which learning outcome we want to aim.

Teaching and Learning Activities

The learning activities should be able to support the students into requiring the learning outcomes that we want them to achieve. These activities can be part of lectures, workshops, field trips or projects. Teachers, peers, the student, and the provided materials all have influence on the outcome of the activities. Within the framework, illustrated in **table 13** we can decide which learning activity would fit for the different stages of the design thinking and maker education process, but also how different activities fit with various learning levels.

Assessment and Grading

In deciding the assessment tasks, it is necessary to judge the extent to which they embody the target learning level of the students, and how well they lend themselves to evaluating the students' performance. In the previous chapter, we discussed four types of assessment: summative, formative, ipsative, and authentic. From our results, we have seen that most practices employ ipsative self-assessment through reflection or formative assessment through observation grids. For these assessment strategies to be successful, we need to clearly align the assessment materials to projected learning outcomes. This way students have a clear goal work towards. And they will perceive the assessment as fair.

Moreover, constructivist philosophy lends itself well to the use of an assessment portfolio that the student creates. Here the student can select evidence of learning that they consider matches the objectives of the learning activities. This further supports the idea of the use of self- and peer assessment. Then, the following issues have to be considered to select the right form of assessment:

1. What qualities of learning are we looking for; what performances need to be confirmed in the assessment?

2. Should the assessment be decontextualized or situated? The answer here depends on the nature of the knowledge; procedural knowledge clearly requires enactment in context, while declarative knowledge may or may not, depending on why it is being taught (Biggs, 1995).

3. Who should set the criteria for learning, provide the evidence, and assess how well the evidence addresses the objectives? All three issues could be addressed by teacher, by peers, by the student, or by all collaboratively.

How will we do it?

As we need to balance the different parts of the curriculum, specifically the learning goals, the learning activities, and assessment tools need to be connected, we need to create a tool that help us align these three curriculum components. **Table 14** is an example of a tool that can helps us reflect on this.

Table 14. *Potential constructive alignment (Biggs, 1996) tool*

Aim	Learning Goal	Taxonomy	Learning Activities	Assessment
Creativity	Divergent Thinking	Remember	Lecture on Double Diamond Process	Summative: Class discussion
Creativity	Divergent Thinking	Apply	Brainstorm	Formative: Observations
Creativity	Divergent Thinking	Analyze	Draw connections between ideas	Summative: Argumentations
Collaboration	Decision making	Evaluate	Dot marking	Formative: Observations

In the first column of the table, we can select an overarching aim of our curriculum: Creative Thinking, Collaboration or Self-Regulation. In the second column, the more manageable learning goal is stated together with a taxonomy level. These together form the projected learning outcome. Connected to this, a learning activity and assessment activity can be chosen.

Lastly, we could choose to add all components of the curricular spiderweb (van den Akker, 2003) to be able to reflect on all facets of the curriculum. Expanding table 14 as follows:

Table 15. *Potential constructive alignment (Biggs, 1996) tool expanded with curricular spiderweb (van den Akker, 2003) components.*

Aim	Learning Goal	Taxonomy	Learning Activities	Groups	Location	Teacher Role	Materials	Time	Assessment
Creativity	Divergent Thinking	Remember	Lecture on Double Diamond Process						Summative: Class discussion
Creativity	Divergent Thinking	Apply	Brainstorm						Formative: Observations
Creativity	Divergent Thinking	Analyze	Draw connections between ideas						Summative: Argumentations
Collaboration									
Self-Confidence									

Evaluation

We have seen that several practices evaluated the effectiveness of their practice. Either through post-intervention questionnaires, observations or even repeated measures experiments. Practices were mostly interested in the experience of the students such as enjoyment, perceived challenge or perceived engagement. Some also evaluated the students' creativity, use of meta-cognitive functions, empathy, self-efficacy, and content learning. To evaluate the aims of our curriculum; boosting self-confidence, collaboration skills, and creativity in students, different methods could be used. For self-confidence, we could employ a within-group measurement of self-efficacy through a self-efficacy scale

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(Sherer et al., 1982). To evaluate collaboration, we could evaluate certain elements of decision making we find important, such as discussions, decision making, and task division processes, and observe whether these happen. Lastly, to evaluate creativity we could use a creativity scale, such as Kaufman's K-DOCS (Kaufman, 2012).

While most of the practices evaluated their aims and objectives, it is notable that teachers are not included in any of these evaluations. To gain a multi-stakeholder perspective it is vital that we evaluate our curriculum with students and teachers.

How can we overcome roadblocks for implementation?

Costs

We found that the Maker Education practices that we analyzed were more often not connected to the school curriculum. This might be explained by the high costs of the materials that are involved in these practices. For example, we found that laptops with specific software were often required for a Maker Education practice. Other practices use robotics kits, like LEGO Mindstorms or Cubelets, or digital fabrication machinery, like 3D printers or laser cutters. The costs of purchase and acquiring knowledge about operation and maintenance of these machines might be too big of an investment for schools and thus work as a roadblock to get started with Maker Education activities. To combat this price roadblock, we might focus on making aspects with tools that schools usually already have within their classroom setting. For example, we could design activities that involve technical construction through basic woodworking or soldering of basic circuits. Another option would be the creation of basic hardware kits around a microcontroller (e.g. microbit, circuit playground, Lilypad or chibichip), like the sparkfun curriculum. These kits would have an initial cost, but are re-usable and can be applied to a wide variety of projects. Lastly, if it is not possible for schools to invest in digital fabrication machinery and the knowledge that is needed to operate and maintain these, we can look if there are ways to involve local industry or maker communities in the project to supplement this need. For example, we can investigate how to support schools in creating relationships with local fablabs or with local makers via 3Dhubs, a network in which individuals provide access to their 3D printer for a small price. However, we need to keep in mind that schools in rural areas might not have the same outreach possibilities as schools in urbanized areas which makes this strategy less generalizable.

Teacher Knowledge, Role and Resources:

In Design Thinking and mixed practices, the main role of the teacher is to give feedback, instruct and motivate. However, in ME the teacher role seems to be more classical with a focus on diagnosing learning gaps, instruction and explanation. This can also be explained by the skill-learning aspect of ME. In skill-learning there is a clear right and wrong: e.g. in the creation of circuits, the underlying physics make it so that there is a finite way a circuit will work. This results in a teacher having to transfer knowledge on the topic and diagnosing when students don't have the right knowledge to fulfill a task.

Giving feedback to students can be a challenging task for teachers. Teachers shouldn't directly instruct the students, nor should tone of voice or body language reveal the teachers' feelings about the students' concepts or artifacts. Teachers can give suggestions, but this should be done to inspire not to influence. Self-reflection on giving feedback to students might help teachers with improving this skill. We can provide the right self-reflection questions for the teacher to use.

Teachers also need to gain knowledge to be able to implement the curriculum. In our results we seen that combination practices sometimes involved a teacher guide to support the teacher with implementing the curriculum. Because Design Thinking and Maker Education are novel philosophies, a guide could help a teacher to implement the curriculum. When creating such a guide we also need to take the various teacher roles into account. In particular, how we can support teachers in adapting these roles. Moreover, these guides need to be intuitive, as teachers might otherwise not have enough time to implement our practice into the curriculum.

Macro-level roadblocks:

To get a multi-stakeholder perspective, we need to take the wishes and needs of macro-level stakeholders into account as well. This includes other school staff and the school board. Our aims and objectives have to be in line or complementary to the aims and objectives of the schools.

Question that we might ask ourselves are: Do schools have the time to implement our curriculum? How do we make sure that the implementation of our curriculum doesn't disturb the students' learning in other sections of the school curriculum? Does our curriculum fit into the pedagogical-didactic approach of a school? Which materials are used in schools now and can we connect our curriculum to these? What is possible in the learning environments within the schools? And what kind of assessment does the school feel comfortable with. Lastly, as our assessment procedures have to fall in line with the agreements made at school level for testing, assessing and valuing what students learn. How do we create a flexible assessment procedure that is in line with the vision of the school, either emphasis on formative assessment and/or giving grades, the national agreements, such as examinations, and the vision on subject and learning areas? We will try to find answers to these questions within our need's analysis.

Conclusion:

In this report, we analyzed 28 practices that incorporated Design Thinking, Maker Education or a combination of both through mapping them to 7 components of the curricular spiderweb (van den Akker, 2003). This brought about the different qualities of contemporary Design Thinking, Maker Education or combination practices. We discuss key

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considerations regarding the creation of a curriculum that combines Design Thinking and Maker Education for students 9 to 14 years old.

There is a need to be flexible in the way learning happens and in the way educators could integrate the DESIGN FUTURES programme as a whole or just some parts of it. Given that time and resources is of the essence, our programme needs to follow a flexible line of reasoning within a **framework**. Such a framework could combine a Design Thinking and Maker Education process that consists out of different phases. These phases in combination with a learning taxonomy would allow curriculum designers to reflect on which activities could facilitate different levels of learning.

The aimed for learning outcomes, learning activities, and assessment procedures should be in line with each other. We propose a tool that allows us to align these three parts. By incorporating the components of the curricular spiderweb to this tool, we can, furthermore, reflect on the different elements we need to put these activities and assessment procedures into practice.

To summarize, it should be noted that through DESIGN FUTURES, we don't aim to create a '**one size fits all'** curriculum but through a clear vision, guidelines, and structure, we hope that our materials can be adapted by teachers to implement in to their practice, culture, and personal needs. This diversity can inspire the further development of our programme and make it context-dependent, cultivating at the same time students' 21st century skills and teacher's professional development, by combining maker education and design thinking processes.

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Appendix A

Practices applied in the DESIGN FUTURES partnering countries (EL, IT, NL, RO)

GREECE

Name of Existing practice	**eduACT**
A photo or logo of the practice would be nice	eduACT The Organisation for Future Education
Country or countries that it is applied	Greece
Institution (running the activity)	eduACT
Implementation year and duration (in hours, and number of sessions)	Ongoing practices: There are various related practices: • workshops (24 sessions in each teaching period) • projects at a regional and/or international level • Contests and Fairs • visits to schools
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Their vision for the future- To bring future education to our world, today! By introducing the concept of innovation into the educational process, they aim to give prominence to the talented young individuals and provide them with stimuli for creativity. Research, playful learning, and fun are put together to equip young individuals with useful skills for future citizens.

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Connection to school curricula (YES/ NO)	NO - informal education
Target and age groups (teachers or students)	CHILDREN from 5 to 15+ (Greek, English, French, German-knowledge is everywhere)
Location(s) (where the activity takes place)	**Fab Lab** mainly. They also take part in world-wide contests and Fairs. There is also a summer camp. Some workshops take place in schools, others in Exhibition Halls.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	**All**: students, teachers, parents, local community, ngos, etc, erasmus+ partners (as they also take part in Erasmus+ programmes), other European project partners
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	project (or task)-based learning design-based learning collaborative-learning, Robotics education building *LEGO*® creations creative design - two-dimensional design, three-dimensional constructions, problem-solving
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or	Change in educational practices towards development and reinforcement of **SKILLS**: By introducing the concept of innovation into the educational process, they aim to give prominence to the talented young individuals and provide them with stimuli for creativity. They aim to equip young individuals with useful SKILLS for future citizens: collaboration, leadership, research skills, creativity, technology literacy, STEM/ STEAM literacy, self-esteem and descriptive expression, algorithmic as well as analytical thinking, ability to solve programming problems.

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reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	Children draw and paint in two or three dimensions, understand their capacities, sizes, number correlation, and programming concepts. At the same time, they practice social skills, work together in small groups, learn to present their ideas and express themselves in multiple and creative ways.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves or the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Assessment is done qualitatively rather than quantitatively, by children themselves and parents, educators, Robotics Experts, through Fairs and Contests. Taking part in European-funded projects, the EU is also both qualitatively and quantitatively, assessing their objectives.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Materials: *LEGO*® Mindstorms, Laptops **Human Resources**: Robotics experts, mechanic engineers, instructors of various specialties, teachers with experience in international educational programs **Know-how**: Robotics, Programming, Coding, drawing and painting in two or three dimensions, mathematics, physics, design, research, presentation.
Success criteria or obstacles identified for the practice	Keys to success: -good collaboration. They build future education by establishing good collaborations. -arousing children's interest in learning through research-based methodologies and fun activities. -offer children the opportunity to show and develop their talents. -need for a network of volunteers who collaborate with important honorary and active university professors.
Further information can be found at: Web/Social Media/contact person, etc.	https://eduact.org/en/about-us/

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GREECE

Name of Existing practice **Greek title**	**Designed for Better Learning** **Έτσι Μαθαίνω Καλύτερα**
A photo or logo of the practice would be nice	ΕΤΣΙ ΜΑΘΑΙΝΩ ΚΑΛΥΤΕΡΑ
Country or countries that it is applied	Greece
Institution (running the activity)	The Athens Partnership coordinates the program for the City of Athens, with the exclusive financial support of the Stavros Niarchos Foundation (SNF), while the Transformable Intelligent Environments Lab (TUC TIE Lab) of the Technical University of Crete is responsible for the scientific planning and implementation.
Implementation year and duration (in hours, and number of sessions)	Ongoing practice from spring 2016 to the present: • Spring 2016 – October 2018 (2.5 years): 1st and 2nd phases of the program: Redesigning Public schools in Athens - physical environment and educational experience. • 2018 - ongoing: 3rd phase of the program: Municipal Maker Space - hands-on experience in digital design and creation. • Plus: 8 weekly seminars/ workshops for Teachers design and, with the guidance of the Architect-researchers of the University of Crete, create their own original game.

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Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Redesigning Public schools: 24 public schools were transformed through this Athens Partnership program, with the **Expertise of the Technical University of Crete's Transformable Intelligent Environments Laboratory (TUC-TIE Lab)**: more efficient interior layouts, upgraded facilities such as bathrooms, unification of previously separated or obstructed spaces, new spaces for students to play and socialize during breaks. Maker Space: An integral part of the Designed for Better Learning program, the Maker Space provides a hands-on experience in digital design and creation. Guided by the **team of architects of the Transformable Intelligent Environments Lab of the Technical University of Crete**, participants can envision and create their own tools, ranging from everyday tools to toys and educational equipment. More than 220 teachers have also already participated in training workshops at Maker Space and creating pedagogical constructs that will **transform the classroom into a fun place to learn**. In 8 weekly seminars, they are invited to design and, with the guidance of the a**rchitects of the Transformable Intelligent Environments Lab of the Technical University of Crete**, to create their own original game. *
Connection to school curricula (YES/ NO)	YES/NO ?- *used by teachers in the classroom, CONNECTION TO CURRICULUM IS VAGUE The other phases of the program – NO
Target and age groups (teachers or students)	nursery, primary and secondary school students & Teachers
Location(s) (where the activity takes place)	Fab Lab, Schools
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	All: Students, teachers, architects, technology experts, parents, local community, ngos, etc
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken:	A groundbreaking approach that combines education, new technologies, and architecture and actively involves teachers, students, and parents in the process and sustainability. A combination of:

problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	• social purpose oriented, involving families/ communities - mainly • problem-based learning • project (or task)-based learning • design-based learning • collaborative-learning In its first two phases, architectural interventions were made in 24 schools in the municipality of Athens, and 87 "Educational Pla(y)ces" - educational projects enriching the learning tools and the school environment. The Maker Space is part of the third implementation phase of the "Designed for Better Learning" educational program. The fabrication lab is free for all students in Athens and is aimed at helping them thrive in using 21st-century technology.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Change in physical environment, equipment and facilities. Change in culture and attitudes towards education by actively involving teachers, students, and parents in the program., esp. for the 4,000 children in the 24 public schools that were transformed through this Athens Partnership program. Development and reinforcement of skills on participants.
Development and/or reinforcement of skills and which ones	Digital skills: The Maker Space provides the school children with resources to explore how to program a robot battle or how you can use a 3D printer to design and produce a chess piece or a key ring. They can even see what it is like to visit a space station using virtual reality. Students work with modern technological applications, exploring STEM (Science, Technology, Mechanics and Mathematics) educational programs. Teachers also participate in training

<table>
<tr><td></td><td>workshops on the use of laboratory equipment and the possibilities they can offer in learning.

Collaborative skills and Initiative: An “Educational Playces” team worked with students and teachers in each of the schools to enrich learning spaces and incorporate educational equipment to enhance learning. Educators placed the process in the hands of students to direct these efforts.

Social skills: communicate, learn, ask for help, get needs met in appropriate ways, get along with others, develop healthy relationships, protect themselves, and in general, be able to interact with others harmoniously.</td></tr>
<tr><td>Assessment/ Reflection of the learning objectives
(Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)</td><td>Assessment by the project impact:
1st and 2nd phase - Redesigning Schools
Surveys after the program’s completion at each site showed a marked increase in student and parent engagement and positive connections with their schools. Teachers were also able to engage students in more collaborative hands-on projects.
77% of school children report leaving school content and happy, while 34% see school as a place of creativity for the first time;
66% of teachers report better predisposed towards their school, while 43% experimented with alternative forms of teaching.
The programme in numbers:
24 public schools redesigned (equal to 5% of all public schools overseen by the City of Athens)
4,215 students and teachers directly impacted
40 requests for replication across Greece
3rd phase – Maker Space
Since its re-opening in 2018, more than 1150 children in Athens have already explored the Maker Space, learning about applied digital technologies through hands-on experiments. More than 220 teachers have also taken part in workshops – designed to help them create new tools to enhance school learning and introduce creative play in the classroom.</td></tr>
</table>

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	The City of Athens' "Designed for Better Learning" program won the **Golden Prize in the "Best Learning Experience" category at the Educational Leaders Awards 2018**, the nationwide prize awarding private and public bodies for best practices in education.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Materials: ○ Redesigning Schools: re-Construction materials, playgrounds, facilities, everyday tools, toys and educational equipment to enhance learning. ○ The City of Athens' Maker Space: the first municipal fabrication lab in Greece, equipped with machinery and digital tools for designing, printing, and manufacturing, i.e. Laser cutters, 3D printers, CNC router, vinyl cutters. ○ Human Resources: teachers, students, parents, local community, expert architects. ○ Know-how: education – technology – architecture.
Success criteria or obstacles identified for the practice	The success indicators are: 77% of the children responded positively to the changes at their school and 43% of the teachers even tested new ways of teaching under the program. More than 1150 children in Athens have already explored the Maker Space. It has given them the opportunity to learn about applied digital technologies through hands-on experiments. More than 220 teachers have also taken part in workshops which are designed to help them create new tools to enhance school learning and introduce creative play in the classroom. One challenge to overcome for the 5 nursery schools that were renovated: they were housed in adjacent buildings that shared a common school yard that was separated by gates, fences and walls. These boundaries divided up the space and created visual barriers between the educators and the children.
Further information can be found at: Web/Social Media/contact person, etc.	**the program's site:** https://athenspartnership.org/education-1 **the program's video**: https://vimeo.com/228501309

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GREECE

Name of Existing practice	**Generation Next**
A photo or logo of the practice would be nice	Generation Next
Country or countries that it is applied	Greece
Institution (running the activity)	Generation Next is an evolution of the Vodafone Foundation's STEM powering Youth training program, launched in 2017 in collaboration between SciCo Educational Nonprofit Organization and the Academic Contribution of Greek-German Education.
Implementation year and duration (in hours, and number of sessions)	From 2018 – ongoing Generation Next organizes 10-week workshops in various regions of Greece, where 13-16-year-old students discover in practice what STEM means, acquire new skills, experiment and create. In each class of workshops, students are trained in the sciences of technology, engineering, and programming using new technologies and interactive tools.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Generation Next is a free-to-access skills development educational program in new technologies and science. The Vodafone Foundation brings a new STEM educational experience and empowers 'today's explorers' to build the dream society of tomorrow. Generation Next is an evolution of the Vodafone Foundation's STEM powering Youth training program, launched in 2017 in collaboration with the SciCo Educational Nonprofit Organization and the Academic Contribution of Greek-German Education, and already counts more than 12,400 students in Greece.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	high school students and teachers

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Location(s) (where the activity takes place)	There is an online platform including different extracurricular activities but also classroom based activities that the participating schools have implemented.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	teachers, students, parents, local community, ngos, etc
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Problem-solving, skills-development Generation Next organizes 10-week workshops in various regions of Greece, where 13-16-year-old students discover in practice what STEM means, acquire new skills, experiment and create. In each class of workshops, students are trained in the sciences of technology, engineering, and programming using new technologies and interactive tools. Each STEM workshop cycle concludes with the creation of constructions that groups of students develop during the lessons, and the emergence of the most innovative ones, which either solve a local community problem or an everyday matter.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Social Innovation and skills development educational program. **Workshops: students** learn basic STEM topics (Science, Technology, Engineering, Mathematics) design and create solutions that solve problems of local society or everyday life. **Teacher training packages:** with STEM equipment, for Physics, Informatics and Technology courses.
Development and/or reinforcement of skills and which ones	STEM practices (Science, Technology, Engineering, Mathematics), Design and Construct (Making)

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	Problem-solving and social innovation: solve problems of local society or everyday life. Digital skills, Research and Creativity: development of IoT (Internet of Things) logic, using Arduino Sensors to create mechanical constructions, and Designing mobile apps. Collaboration, Communication and Critical thinking – working in groups to think of ideas and invent things that solve problems.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	To date, 41 secondary schools and 2 NCEs (Natural Science Research Centers) have been provided, specially designed training packages with STEM equipment, for Physics, Informatics and Technology courses, with the aim of enriching the lessons and adopting collaborative education in the classroom. In this way, the Vodafone Foundation has managed to empower 11,100 students to date in schools in Thrace, Thessaly, Central Greece, the Peloponnese, Crete, and the Ionian Islands, the North Aegean and of the Dodecanese.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Materials**:** • **Teacher training packages** with STEM equipment, for Physics, Informatics and Technology courses • 3D printers, Arduino Sensors • STEM equipment, for Physics, Informatics and Technology courses Human resources: STEM, Arduino, IT experts. Knowledge: STEM/ Arduino/ IT expertise.
Success criteria or obstacles identified for the practice	The success indicators are: • To date, through STEM workshops, 1,250 students and 52 teachers have been trained in 47 regions of the country, from Thrace, Epirus, Thessaly, and the Northeast. Aegean to the Dodecanese, Crete, the Ionian, the Sporades, and the Peloponnese. • During the 2018-2019 academic year, 95 innovative small researcher constructions emerged, and the following were highlighted for the creativity and knowledge gained from the workshops.

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	• To date, 41 secondary schools and 2 NCEs (Natural Science Research Centers) have been provided, specially designed training packages with STEM equipment, for Physics, Informatics and Technology courses, with the aim of enriching the lessons and adopting teamwork and teamwork. education in the classroom. In this way, the Vodafone Foundation has managed to empower 11,100 students to date in schools in Thrace, Thessaly, Central Greece, the Peloponnese, Crete, and the Ionian Islands, the North Aegean and of the Dodecanese.
Further information can be found at: Web/Social Media/contact person, etc.	**info about the program:** https://www.vodafonegenerationnext.gr/about-us https://www.vodafone.gr/vodafone-ellados/idryma-vodafone/programma-generation-next/ **Digital platform, with free access to discover/learn/create STEM practices:** https://www.vodafonegenerationnext.gr/ **video about the program (in GR):** https://youtu.be/UKJ5NRPLUb0

GREECE

Name of Existing practice	**Eureka! Past, Present and Future!** Erasmus+ KA219 2016-1-UK01-KA219-024237_2
A photo or logo of the practice would be nice	
Country or countries that it is applied	Erasmus+ KA219 Strategic Partnerships for Schools Only/ «Co-operation for Innovation and the Exchange of Good Practices» Greece, Scotland (co-ordinator), France, Italy, Romania

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Institution (running the activity)	Aristotelio College, Thessaloniki, Greece Craigclowan Preparatory School,Perth, Scotland, UK (co-ordinator) Ecole Saint Victor, Paris, France Istituto Comprensivo Rina Monti Stella, Verbania Pallanza, Italy Scoala Gimnaziala nr.14, Braşov, Romania
Implementation year and duration (in hours, and number of sessions)	From September 2016 to November 2018 (26 months)
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	This project fostered entrepreneurship, from an early age, and the idea that anyone has the capability of being an inventor. It aimed to inspire young people, build on their sense of initiative and show them that through collaboration, hard work, and good leadership, they can be the next generation of inventors. The participants of this project (students and teachers) were finally endowed with a set of life-long skills, which can only enhance their future as EU citizens and valuable members of the labour market.
Connection to school curricula (YES/ NO)	YES - ENGLISH CLASS, ICT CLASS, ART CLASS
Target and age groups (teachers or students)	primary and secondary school students (aged 8-14)
Location(s) (where the activity takes place)	Schools – turned into maker spaces.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Students, teachers, parents, local community, local governors, chambers of commerce, local/ national/ international press, eduACT, 3D printers' etc).
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken:	Problem-based, Project- based, Social purpose-oriented learning Design Thinking and Maker Education Entrepreneurship in education 1. Research into Inventors & Inventions of each country made into presentations (ppt, videos, factsheets) 2. Project Logo competition

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problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	3. Model making of past inventions (prototypes made from simple materials to Robotics/ LEGO Mindstorms) 4. Students' own Inventions: Design-thinking process 5. Manufacturing of students' inventions: Maker Space 6. Exhibition of inventions at the "European Youth Invention Ideas Fayre" in Perth, Scotland: Entrepreneurship
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Change in attitude towards educational approaches. Change in attitude towards the European project. Development of skills in students and teachers. Learning objectives: • Students learn to research into past inventions . • To act as inventors: think of a problem, collaborate to solve it, think of an invention to solve the problem, design the invention, design its components/ materials needed, produce an analytical breakdown of how the invention works. • To think and act as entrepreneurs: organize the promotion/ marketing of the invention (slogan, poster or radio commercial or TV commercial, Elevator Pitch), calculate the cost of manufacturing, the final price. • To think as ecologists: how ecological the invention is.
Development and/or reinforcement of skills and which ones	• Collaboration • Critical thinking • Communication & presentation • Entrepreneurial skills • sense of initiative • Research • Design • manufacturing • competence in foreign languages • digital competence: ICT/ robotics/ 3D animation • understanding of linguistic and cultural diversity

	• positive attitude towards the European Project
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Children themselves, teachers, parents on an impact survey: An Evaluation Survey assessed the impact of the project. The results of this survey showed: Almost all knew about the project. The vast majority had read about it in the school website & on the e-learning platform. More than half of the participants had visited Eureka FB, Instagram. 4 out of 6 had read about it in the school yearbook. More had, themselves or their children, been involved in the project in some way. The Teachers' Manual will help primary schools who wish to conduct such projects. The Dissemination Document-Magazine that partners published after they got an ISBN Nr, will inspire fruitful European partnerships.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Materials: • For the prototypes of the winning inventions - from simple materials to 3D printers • For the actual inventions - robotics (LEGO Mindstorms) • Designing Android applications - Coding Human: • Android experts • EduACT/ Robotics experts Templates: • All partner design-thinking resources were shared and eventually compiled the "Teachers' Guide" addressed teachers interested in implementing a Design project in their school.
Success criteria or obstacles identified for the practice	Promoting a life- long learning perspective and entrepreneurship education were the key priorities of this project. The results of this project culminated in 24 invention ideas being promoted at the European Youth

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	Invention Ideas Fayre which was held in Perth in June 2018. This involved 85 pupils presenting their inventions. We have the new generation of European inventors, who thought of something original, worked hard, in team-spirit under the teachers' guidance & external agents' leadership, towards making the inventions happen. They worked on the promotion of the inventions, so they are young entrepreneurs too. All students worked in collaboration on each other's research into past Inventions first, invention/ ppt/ video/ commercial/ elevator pitch/logo/posters. They worked together on manufacturing robots/3D models/apps-there were many groups of students overlapping between projects. Team-spirit was built and a sense of striving for the same purpose no matter which/whose invention or robot they worked on. European projects widen students' & teachers' scope, further enhance the educational curricula & provide the right motivation to students & staff to be part of something creative. The final exhibition in Perth was 'A FAYRE'-a celebration. Students communicated in English, explained their inventions to people present at the Fayre and then at a Craigclowan assembly and applauded all invention ideas. The objectives of Eureka have been reached is • to increase participants' sense of initiative and entrepreneurship: students researched into past inventions & then thought of something original, designed, implemented an invention, thought of the marketing. The Best Invention Competition took place. Invention ideas that had been best worked on travelled to Romania/Scotland with the inventors. • to increase competence in foreign languages: all students used English to present their invention ideas, what they were composed of, how they worked & the marketing campaign, and to communicate with Erasmus partners. Students tried to speak Greek, French & Romanian when visiting these countries. • to increase the level of participants' digital competence: New technology & programs were used throughout this project - Robotics, Google Education suite, 3-D and laser printing, communications software • to provide opportunity to research, design, create, manufacture & present an invention: In Invention workshops pupils/staff learned a lot about the design process & how anyone can be an inventor. Robotics/3d model/android application workshops provided students/staff with the know-how to

	become designers of products. A Teacher's Guide has been produced as an outcome of this. • to foster tolerance to linguistic & cultural diversity: Students got in touch with language & culture of the country they visited. All pupils/staff loved preparing for the exchange, making new friends & learning about life abroad. Erasmus students keep in touch with host families. • to foster more positive attitude towards the European Project: Appreciation & knowledge of the EU has been built. Working for a better united Europe has been instilled in the heart of future inventors. Other exchanges were also organized outside this project, but as a result of it. In conclusion, participants have been endowed with a set of life-long skills that can enhance their future as EU citizens & valuable members of labor market: digital & linguistic competence, collaboration, sense of initiative, entrepreneurship, creativity, inventiveness, tolerance. Getting to know foreign educational systems fascinated the educators. This was a truly cross-curricular project involving ICT/ART/Drama/CDT/Language this was innovative and motivating for staff. Staff shared educational practices & pedagogical approaches. Multi-focal teaching produces broad learning experiences. Management of such a demanding project by staff has improved class management & project implementation skills. OBSTACLES: • for schoolteachers to proceed into producing the templates for the DT process and the evaluation criteria of the inventions. • for schoolteachers and young students to proceed into making the inventions, using knowledge they do not own (3D animation, Robotics, android app coding etc). Some did not have even basic IT skills. So students and teachers collaborated with experts, and the result was several unique working inventions!
Further information can be found at: Web/Social Media/contact person, etc.	**the project site:** https://sites.google.com/a/craigclowan.org.uk/eureka-past-present-and-future/home **the project fb:**

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	https://www.facebook.com/profile.php?id=100013919112971 **ARISTOTELIO COLLEGE WEBSITE under tag name "Ενημέρωση" and particularly "Διεθνή Προγράμματα"** **https://www.aristotelio.edu.gr/web/**

GREECE

Name of Existing practice	**STEM in schools**
A photo or logo of the practice would be nice	STEM education ΟΡΓΑΝΙΣΜΟΣ ΕΚΠΑΙΔΕΥΤΙΚΗΣ ΡΟΜΠΟΤΙΚΗΣ, ΕΠΙΣΤΗΜΗΣ, ΤΕΧΝΟΛΟΓΙΑΣ & ΜΑΘΗΜΑΤΙΚΩΝ
Country or countries that it is applied	Greece
Institution (running the activity)	STEM Education
Implementation year and duration (in hours, and number of sessions)	From 2015 – ongoing Their programs last suitable teaching hours (most of them 90 minutes) for each course and they last a school year.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	The organization STEM Education uses the **STEM** approach [**S**cience, **T**echnology, **E**ngineering and **M**athematics] in all their activities, as they try to transform the education from the traditional teacher-centered teaching to a teaching where problem-solving, and discovery-inquiry learning will play a dominant role in the curriculum, while the processed require creative engagement of learners in the discovery of every solution. They have several and quite different programs, as the organization offers educational programs in engineering, coding, mathematics, and science. Their aim is to create a new generation of children who have innovative abilities to solve problems, using elements from all scientific fields and be prepared for the future society that is being shaped at a very fast pace. They also have programs for schools, where they give the students the opportunity to get in touch with STEM elements and educational robotics.
Connection to school curricula (YES/ NO)	NO

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Target and age groups (teachers or students)	In general, their programs aim to students, from kindergartens to high schools. Their schools' workshops aim at primary and secondary schools.
Location(s) (where the activity takes place)	The organization STEM education has formal learning spaces in their 4 educational centers, where their courses are taking place. Furthermore, they design educational programs and workshops in primary and secondary schools, according to the age and the experience of the students.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	The teachers of the organization, which are trained in the elements of STEM education.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	They have many programs for different ages. Here, we will analyze a program that is called Young Engineers, which is designed for 6-7 years old pupils with 30 different activities which one of them lasts 90 minutes and inside the classroom can participate 16 students. This program is based on making education. Thinking and acting as true engineers, with original constructions, students can create applications of simple machines in order to find solutions to everyday problems. The program has introductory concepts to the world of engineering, analysis of design and construction techniques, necessary equipment, explanation and use of gear, wheel, axle, lever, and pulley. And at the end of the program children are involved in teamwork and creative projects, expressing their own ideas.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic?	The programs of STEM education can help the students to learn many technical and scientific skills, like robotics and coding. As they focus on STEM practices, students can explore deeply the aspects of science, technology, engineering, and mathematics, while they develop their technological knowledge and they are being supported in their school performance with a better and more efficient understanding of practical subjects, like physics, mathematics, computing. Furthermore, students become more familiar with the natural sciences and new technologies, as they have the opportunity of an open exchange of views and collaborations with all those who are interested and involved in the fields of new technologies and several scientific topics.

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▫ A change in the development and/or reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	Children learn new skills through basic building techniques, simple mechanisms, and motion, which are not a part of the public education. The program boost students' confidence in problem-solving and they learn how to act in a team spirit. Through maker education, children learn in a playful way, as they explore new skills in practice and it encourages them to love science and engineering, by exploring their inclinations.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	They have assessment procedures inside their courses, as the learning is continuous throughout the school year. No assessment procedures are mentioned in their schools' workshops.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Depending on the age and level of knowledge, children can respectively attend the courses. Inside their programs, they have all the required materials, like for engineering, robotics and coding.
Success criteria or obstacles identified for the practice	Through their programs, children participate in real interactive experiences, in which the creatively shapes the frames for their daily lives. They contribute to the cultivation of laboratory culture, as children perform science experiments under the supervision of STEM Education teachers. Students also become members in a globalized environment after accessing educational content that is fully in tune with the new trends of the age at the global level.
Further information can be found at: Web/Social Media/contact person, etc.	**The STEM Education website:** https://stem.edu.gr/ **Program's website:** https://stem.edu.gr/en/lesson/young-engineers/

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	Program's video: https://youtu.be/fHqj-7js9dA

ITALY

Name of Existing practice	**Progetto SET - Scuola e Territorio**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Italy – Modena and Bologna provinces
Institution (running the activity)	Confindustria Emilia, Ufficio Scolastico Regionale, Fondazione Golinelli, PACO Design Collaborative
Implementation year and duration (in hours, and number of sessions)	From 2016 – ongoing
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	An educational program that supports children in designing a new start up starting from an innovative product. The program runs from September to May in the afternoon school classes (two hours for each class per week).
Connection to school curricula (YES/ NO)	YES. The project is running during school hours. Design Thinking is considered as a subject.
Target and age groups (teachers or students)	Children, age 12-13-14

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Location(s) (where the activity takes place)	Classroom, formal learning space, etc. The activities take place in the school classroom. At the end of the program there is a presentation fair that takes place at the project partners headquarter.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Parents are attending only the final presentation. Teachers are involved at the beginning of the program with a short Design Thinking training course. The aim is giving a rough idea of the method. Companies are involved when students go visit them during the class trip.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	The students start designing an innovative product and around that they define a business plan and a communication strategy. The methodology used is Design Thinking, an approach able to develop and implement creative processes and critical thinking to solve problems of different nature. It's a method that teach through the experience, that accept the challenge as a moment of learning and that educate the value of sharing. Program phases: ***Discovery*** The first activity is the research of needs and opportunities. It is a phase of observation, interviews and listening and research that will lead the small entrepreneurs to discover the specific problem they want to solve. ***Start-up*** After identifying the business opportunities, the students form the groups and with a roleplay game they define roles and responsibilities of their small company. ***Design*** The groups write on post-it ideas in full freedom. The post-it are shared, and a participatory and common solution is designed. In the same way that sketching helps small entrepreneurs to think and develop ideas, "quickly prototype" helps to visualize and test new solutions. Using prototyping materials cheap and raw (cardboard, adhesive tape, waste material ...), introduces into the perspective of early failures. Learning and acceptance of these failures and errors are fundamental elements to be transferred to children. ***Testing***

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	Feedback are important in the Design Thinking process. In this phase teachers, parents, professionals from companies test the student project by expressing feedback about its usefulness in the market and its propensity for business. Students gather an opinion from experts about what works and what can be improved. ***Solution development*** Based on the feedback received, students are guided by their tutors to move from the concept to the final solution. The solution is translated into a final prototype. The final prototype is made in collaboration with a local Fablab. ***Business Model*** To ensure that the solution is economically and environmentally sustainable, a business model canvas and a business plan is created. ***Communication*** Each group edit a presentation video that describes the features of the solution, how and why to use it. At the end of the program all the students present their projects to friends and parents during an open fair.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Students explore and learn a new methodology (Design Thinking) based on problem solving that will help them in finding solutions even for complex problems. Working in groups with different roles and creating something from scratch increase their self-esteem. They feel directly involved in a project and they take responsibilities. With this project students get closer to local entrepreneurs and the business sector.

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Development and/or reinforcement of skills and which ones	Creativity, critical thinking, problem solving, learning by doing, curiosity, working in groups.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Reflection moments are always present during the program. Facilitators are 100% part of the school teaching staff. They give feedback to parents twice a year during the parents' days.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Students use machines like rapid prototyping, laser cutter, for the final prototypes. For this project Fablab is collaborating in providing these machines. Human resources.
Success criteria or obstacles identified for the practice	At the final open fair, the visitor number is always high. Every year the project is repeated since 2016 and the number of class participating into the project are increasing.
Further information can be found at: Web/Social Media/contact person, etc.	http://www.designschoolforchildren.com/portfolio-items/startup/

ITALY

Name of Existing practice	Riconnessioni
A photo or logo of the practice would be nice	RICONNESSIONI
Country or countries that it is applied	Italy, Piedmont

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Institution (running the activity)	Compagnia di San Paolo - Fondazione per la Scuola in partnership with OpenFiber and in collaboration with the Ministry of Education, Universities, and Research, the Piedmont Office of Education, and the city of Turin.
Implementation year and duration (in hours, and number of sessions)	2017 - ongoing
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Riconnessioni is designed to eliminate the physical and cultural barriers that prevent schools from innovating. It works on two levels: firstly, innovating the spaces and times devoted to learning and developing new professional competences in schools. Secondly, introducing a new model of internet connectivity for schools designed to enable individualized and interactive pedagogical models.
Connection to school curricula (YES/ NO)	No
Target and age groups (teachers or students)	School and teachers of primary and lower-secondary schools
Location(s) (where the activity takes place)	Classroom, formal learning space, etc. The training is made in person, in formal learning spaces. The practical application with the students takes place in class.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, headteachers and heads of administrative services, parents.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented,	RICONNESSIONI proposes a model based on 4 elements/levels of intervention: 1. FIBER-OPTIC BROADBAND - Schools must be guaranteed fast, safe, and neutral internet connectivity via fiber-optic broadband 2. NEXT GENERATION NETWORKS - the connectivity infrastructure must meet the needs of teachers and learners and lead to improved performance and safety 3. PEDAGOGICAL AND PROCEDURAL INNOVATION - Schools are in the foreground of change and are directly engaged through a commitment to innovative pedagogy 4. PROFESSIONAL DEVELOPMENT - the building of communities of practice, as well as innovative

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involving families/ communities)	methodologies and pathways for professional development is at the heart of the innovation programme.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	The objectives of Riconnessioni are: Innovation, Inclusivity, and Creativity for the Schools of Tomorrow. Riconnessioni brings systemic change, accompanying the schools through processes of technological, organisational, and educational innovation. Riconnessioni aims at building the school of the future.
Development and/or reinforcement of skills and which ones	• developing new management skills • developing design skills like project-based learning • learning digital content creation skills • innovative pedagogy and inclusivity • Computational thinking
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process,	Human resources for the training and resources for the fiber-optic broadband.

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materials for making, machinery for making, etc.)	
Success criteria or obstacles identified for the practice	Numbers: 140 HEADTEACHERS 1800 TEACHERS 98000 PUPILS 4200 KILOMETRES OF FIBER-OPTIC CABLES LAID 10 Gbps BANDWIDTH PER SCHOOL BUILDING 4700 ACCESS POINTS AND SWITCHES
Further information can be found at: Web/Social Media/contact person, etc.	https://www.riconnessioni.it/en

ITALY

Name of Existing practice	**Webecome**
A photo or logo of the practice would be nice	WEBECOME
Country or countries that it is applied	Italy
Institution (running the activity)	Intesa Sanpaolo
Implementation year and duration (in hours, and number of sessions)	2018 - ongoing
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Webecome is an educational offering for primary schools that supports teachers, head teachers and parents on pathways to prevent and combat social hardship and to develop boys' and girls' transversal skills.

Connection to school curricula (YES/ NO)	No
Target and age groups (teachers or students)	Primary school teachers, head teachers and parents.
Location(s) (where the activity takes place)	The training is made through a web platform. The practical application with the students takes place in class.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Different professionals are involved for the content's creation: anthropologists, pedagogists, researchers, psychologists, teachers.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Webecome provides an online platform with 8 themed pathways developed with over 60 experts from different research specialisms. The videos, worksheets, tools and in-depth information provide education community stakeholders with content tailored to their specific roles. The content includes an array of expert video interviews, educational videos, infographics, in-depth information, bibliographies and planning tools for creating positive, engaging classroom experiences.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic?	Providing effective ways to prevent and combat hardship in its various forms and to develop pupils' transversal skills. Each topic is tackled in a positive, proactive approach. The aim is not to stigmatise poor behaviour but rather to develop and reinforce positive habits, sensibilities and attitudes that, if properly encouraged and rewarded, reduce the risk of the children experiencing hardship.

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▫ A change in the development and/or reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	The Growing Up Alphabet underlines the positivity, associating each themed pathway with a keyword, an “antidote” to the problem in question: A for attitude (transversal skills), G for gusto (nutrition), R for relationships (digital citizenship education), S for support (cyberbullying), T for togetherness (against bullying), U for uniqueness (diversity) and W for wellbeing (dependency). Webecome reinforces the teacher’s guiding role, enabling them to adapt and personalise the educational tools to their class’s requirements.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	A series of interviews have been collected and uploaded on the platform as case studies of successful experiments.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	None, all the material is free and online.
Success criteria or obstacles identified for the practice	150 videos to explain the project and provide in-depth educational materials 1300 hours of training available online 60 experts
Further information can be found at: Web/Social Media/contact person, etc.	https://www.webecome.it/

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ITALY

Name of Existing practice	**IDeAL - Didattica laboratoriale nei poli tecnico-professionali**
A photo or logo of the practice would be nice	DIDATTICA LABORATORIALE NEI PTP
Country or countries that it is applied	Italy, Tuscany
Institution (running the activity)	INDIRE
Implementation year and duration (in hours, and number of sessions)	2015 - Ongoing
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Promoting a new educational program based on laboratory methodology. The program is focused on the main school subjects (Italian, mathematics, science and foreign languages). The training course takes place in presence and online on the dedicated platform.
Connection to school curricula (YES/ NO)	YES
Target and age groups (teachers or students)	Italian, mathematics, science and foreign languages teachers of 14-15-16 years old students. The schools involved are all poli-technic schools.
Location(s) (where the activity takes place)	Classroom, formal learning space, etc. The training course takes place in the school and online on the dedicated platform. The practical application with the students takes place in class.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers of poli-technic schools.

Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Teachers follow the "Iterative Design for Active Learning" (IDeAL) course with INDIRE experts. Iterative Design for Active Learning (IDeAL) is an educational approach based on the production of virtual and physical objects in the classroom. It is based on a methodology focused on the iterative design cycle able to enhance the mechanisms of cognitive activation of the students. After the course, teachers apply the IDeAL methodology in their lectures with their students. At the end of the year, all the teachers involved in the training, participate and share their experience at a final convention.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	A change in engagement/interest in learning contents regarding 4 main subjects: Italian, mathematics, science and foreign languages. Data says that the highest number of educational debts, repetitions and drop-outs is concentrated during the first two years of college (data related to the Italian context). A new methodology based on learning by doing is a support for the students that have difficulties in learning notions.
Development and/or reinforcement of skills and which ones	During the training, teachers are learning and experimenting with innovative teaching approaches in which the enabling role of ICT is central: • Flipped Classroom • Debate, • Digital Educational Content Integration/Text Books • Coding • Self-regulation strategies and study method • "Think, Make & Improve" cycle and 3D printers

	• Dependency Grammar
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	In final event all the teachers involved in the training, participate and share their experience at a final convention. All the presentations are updated online and shared as inspirational case studies for other teachers.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Human resources for the training.
Success criteria or obstacles identified for the practice	The programme is at its third edition.
Further information can be found at: Web/Social Media/contact person, etc.	http://www.indire.it/progetto/didattica-laboratoriale-poli-tecnico-professionali/documentazione-seminario-conclusivo-2018-2019/

ITALY

Name of Existing practice	**Codemotion kids!**
A photo or logo of the practice would be nice	kids!
Country or countries that it is applied	Italy

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Institution (running the activity)	Codemotion Kids!
Implementation year and duration (in hours, and number of sessions)	From 2014 - ongoing
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	The Codemotion Kids School of Technology and Creativity is one of the reference points for the technological education of children and young people. In the headquarter office in Rome, various activities take place: • Annual workshops where young participants use coding, robotics, electronics and design to create and bring their ideas to life. • Saturday Tech - four two-hour ludo-technology workshops on different topics to discover the use of technology as a creative tool • AdaLabs - Women's Technology Labs to break down the scientific and technological gender gap and train the innovators of the future The educational model is not based on face-to-face lessons, where participants must listen to the teacher explaining. Facilitators help participants in developing knowledge and skills in a laboratory way, experimenting and exploring, learning to self-learn. They train them to look at technologies as tools to explore, which we don't be afraid of. They train them to live with error, without this being considered a failure, but a step towards knowledge.
Connection to school curricula (YES/ NO)	No
Target and age groups (teachers or students)	Kids 8-18 years old Codemotion Kids has activities divided by age group: 8-10 y.o., 11-13 y.o., 14-18 y.o.
Location(s) (where the activity takes place)	In a formal learning space, the Codemotion Kids headquarter.

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Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	In addition to the workshops, Codemotion Kids works with companies and institutions in the organization of technology edutainment events.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Everyone's talent, creativity and potential are values to be discovered, encouraged and developed. That's why Codemotion Kids educate the young innovators of the future on using technologies as a fundamental tool to express themselves. Technology as a tool to invent and create solutions to real problems. The educational method used is the Creative Learning. Creative learning is based on passion, collaboration, exploration, experimentation and above all on the game. Game is one of the most intense moments and rich in learning experiences. Doing, assembling, experimenting, are activities that increase kids' self-awareness. Codemotion kids build its methodology on the construction model proposed by Seymour Papert and developed at MIT in Boston. The model believe that knowledge is not transmitted passively but it is developed in everyone through the experiences of building something.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Codemotion kids foster the creative use of technologies as a tool for building ideas. Head, hands, heart and imagination are the main tools for writing the future. By mixing manual skills and digital skills, our future innovators will learn to think, create, program, understand and solve problems.
Development and/or reinforcement of skills and which ones	Storytelling, role-playing games, hackathons and showcases are aimed at encouraging, developing and rewarding the talent of future thinkers, engineers, designers, craftsmen.

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Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Human resources – the facilitators Materials and machines for coding and making A learning space
Success criteria or obstacles identified for the practice	
Further information can be found at: Web/Social Media/contact person, etc.	https://codemotionkids.com/

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THE NETHERLANDS

Name of Existing practice	**Platform Maker Education**
A photo or logo of the practice would be nice	maker education leren door te maken
Country or countries that it is applied	The Netherlands
Institution (running the activity)	Multiple: Waag Society, FabKlas, iXperium and more
Implementation year and duration (in hours, and number of sessions)	2018. No activities are specificed.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	It is a platform that connects all working with Maker Education in Netherlands around a yearly conference and to share Maker Education activities.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Primary and Secondrary, and teachers of both.
Location(s) (where the activity takes place)	Please select among the following and explain: • Classroom, after school program, • Community lab, FabLab, etc. • Science centre, library, • Everyday life (e.g. personal hobbies.).
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, Teacher training insitute, libraries, companies.
Brief description of the main activities and pedagogical approach followed	In collaboration with the international FabLearn, we organize creative education conferences with a leading program of speakers, master classes, expert meetings and workshops at the intersection of creative industry and

(Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	educational innovation. Get to know, learn and experience everything in the field of Maker Mindset, Maker Skills, Maker Tools & Materials and Facilitating learning by making. During the seven regional Maker Faires and the national Eindhoven Maker Faire we present the best that Netherlands Maakland has to offer. Experienced and experienced are central here. Here we make the development from young maker to professional visible in themes and activities. In the run-up to the educational conference with FabLearn on Friday, September 28, we organize Maakchallenges throughout the Netherlands. We want to encourage as many children as possible, at home or at school, to experiment, research and make fun. The introduction to technical education becomes more accessible for schools with a visit to a Fablab. We facilitate such a visit. Teachers can become acquainted with new technologies and get to work with their students themselves. With the voucher system, which is made available to 35 schools, we strengthen the cooperation between education and maker spaces.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic?	Very general: Get to know, learn and experience everything in the field of Maker Mindset, Maker Skills, Maker Tools & Materials and Facilitating learning by making.

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▫ A change in the development and/or reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	None available
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	A lot of tool and specific technical knowlegde
Success criteria or obstacles identified for the practice	Access to the technical tool and specific technical knowlegde could form a barrier for many.
Further information can be found at: Web/Social Media/contact person, etc.	https://makereducation.nl/

THE NETHERLANDS

Name of Existing practice	**Ontwerpend leren in de klas** (Design based learning in the classroom)

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A photo or logo of the practice would be nice	
Country or countries that it is applied	The Netherlands
Institution (running the activity)	Wetenschapsknooppunt TU Delft in collaboration with Studio Meeple
Implementation year and duration (in hours, and number of sessions)	From 2014 - ongoing
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	This project wants to bring design based learning into the Dutch primary classrooms to teach children 21st century skills. It works by offering lesson plans and design tools for each step of the design thinking process. The tools are well designed and easy to use and access for the teacher.
Connection to school curricula (YES/ NO)	YES, the connection is made to Science and Technology lessons.
Target and age groups (teachers or students)	For primary school children aged 4-12 years The activities are offered for 3 ages groups, 4-7 years, 8-9 years and 10-12 years. The materials are all made for the teacher to use with the children.
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc. The activities and lesson are meant to be used in the classroom
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	While the project is mainly for teachers it does explain how the teacher can involve parents as experts in the activities. The activities were all developed together with teachers.
Brief description of the main activities and pedagogical approach followed	This project is a great example of designbased learning. The teacher can use either lessons which have been put together around a certain theme in steps of problem

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(Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	discovery, ideation, choosing an idea, making a prototype, testing and presenting. The teacher can also decide to design their own project and ca select from a whole range of tools and templates to use at each design step. The projects wants to make learning 21st century skills effective? 'Ontwerpen in de klas' describes the seven most important skills for learning to design. Very practical and applicable. The 7 exercise cards describe the design skills in student language.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	The project offers 19 teaching methods to help teach the whole class to design: They call the skills: - Think in in multiple directions - Brining ideas to life - Empathise - Choose your direction - Dare to try things out - Share your ideas - Use the process
Development and/or reinforcement of skills and which ones	Other learning objectives are offered per lesson and are often usually knowledge from different science domains such as some biology or physics.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the	While in each lesson the different learning objectives are stated at the beginning of the lesson it is not clear how either the child or the teacher will know if the learning objective has been achieved.

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duration of the programme?)	
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	All the tools to be used in the class such as templates and cards can be downloaded from the website. Other materials needed are simple like straws and tape card cardboard.
Success criteria or obstacles identified for the practice	The materials are well designed and look very easy to use. The ready to go materials I suspect are much more likely to be used that the modular tools as most teachers don't know enough about the design process to create their own path. That being said the modular way it is set up means teachers can pick and mix.
Further information can be found at: Web/Social Media/contact person, etc.	https://www.ontwerpenindeklas.nl/over-ons/

THE NETHERLANDS

Name of Existing practice	**My Machine**
A photo or logo of the practice would be nice	
Country or countries that it is applied	The Netherlands, Belgium, South Africa, Slovakia, USA
Institution (running the activity)	My Machine, Belgium.
Implementation year and duration (in hours, and number of sessions)	The program started in 2009. It takes a full academic year, but not clear how many hours.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence	Whether you want to solve a challenge in your job or neighbourhood, create your own company or whether you want to come up with a solution for a global issue, all require bold action to bring your idea to life. This is where

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and role of facilitator, if present)	MyMachine delivers the "I can do that" perspective to all participants.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Primary school, Secondary school, Higher education, they work together.
Location(s) (where the activity takes place)	Please select among the following and explain: • Classroom, formal learning space, • challenge
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Primary school, Secondary school, Higher education, they work together.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	STEP 1. IDEA: children from primary schools invent and present (via drawings, models, manuals, ...) their own 'Dream Machine'. Anything goes: from a machine that helps you to put peanut butter on a sandwich to a machine that cleans your room. The main criterion is that it's relevant for the child who really wants it. STEP 2. CONCEPT: higher education students (e.g. product design, game design students, engineers, architect students, art students) propose one or more solutions to design those machines. The best solutions – according to the children – then are selected and further developed. STEP 3. WORKING PROTOTYPE: finally, the technical drawings/designs and working concepts are handed over to Technical Secondary Schools . They build real prototypes of those machines, assisted by the kids who invented them and the higher education students who designed them. Throughout this whole process the children, pupils and students can use the expertise and support of a wide range of local corporations and organizations who share a common view on creativity and innovation.

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Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	**Higher Education Students** go through an amazing hands-on experience (including budget restraints and deadlines) of their future jobs: They learn to listen to their customer, in this case the Elementary School child (a very demanding customer by the way). They learn to use their own knowledge and knowhow to translate the idea into a concept. They learn to take into account the production facility they can use, in this case the participating technical secondary schools: they need to understand what production machines these schools have, what complexity level the participating technical secondary school students can handle. **Technical Secondary Students l**earn about the valuable contribution they make in a product design flow: They learn that in many cases they can actually improve the design of the engineers. They learn to communicate about how they know the production could be made easier and better. They learn the importance of their skills as an important asset of the materializing of ideas and the creation of added value. **Elementary School Children learn** that the world in which they live in is malleable and that they can actually contribute to society, rather than just be a consumer of society: They learn that having ideas is important and brings joy and wonder. They learn what it takes to bring an idea to life. They learn the importance of STE(A)M, entrepreneurship, respect each other's talents, collaboration in groups, co-creation.

Development and/or reinforcement of skills and which ones	
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Not available on the website.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Not clear from website.
Success criteria or obstacles identified for the practice	You have to connect three schools to collaborate.
Further information can be found at: Web/Social Media/contact person, etc.	http://mymachine-global.org/

THE NETHERLANDS

Name of Existing practice	**Designathon Works**
A photo or logo of the practice would be nice	

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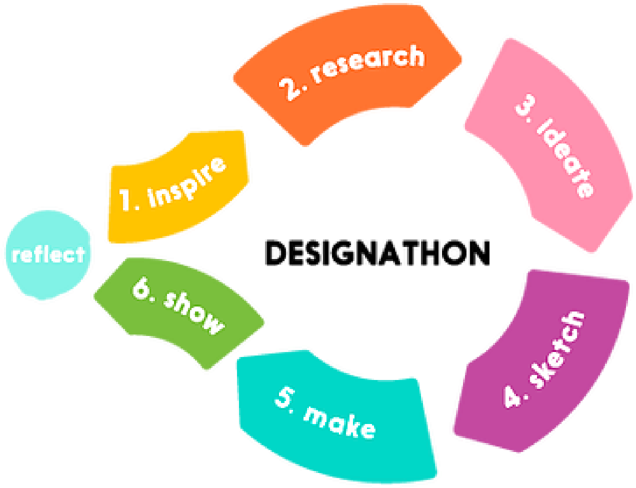
Country or countries that it is applied	45 countries all around the world.
Institution (running the activity)	Stichting Designathon Works
Implementation year and duration (in hours, and number of sessions)	Started in 2014 and ongoing. A designathon workshop lasts four to six hours. Children can do mulitple designathon workshops over different themes.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	A designathon is a structured workshop in which children (ages 4 - 12 years) invent, build and present their self-devised solutions to a social or environmental issue around the Sustainable Development Goals. A workshop lasts four to six hours and is facilitated by education professionals.
Connection to school curricula (YES/ NO)	YES, connected to science and technology lessons in primary school.
Target and age groups (teachers or students)	7-12 years
Location(s) (where the activity takes place)	All of these are used by differenrt partners for the designathon: • Classroom, as an in school program. • Community lab, the program is also run in the Maakplaats, the city of Amsterdam' makerspaces in libraries. • Museum, science centre, • The progrma has been run in NEMO and in Singapore science museum. • Challenge, twice the program has been run as a challenge were schools or groups and take part and send in their ideas.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, parents, municipalities, schools, ngo's, businesses and other partners.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken:	Design-based learning, collaborative-learning (the children search for a solution in groups), creative thinking through a creative process.

<table>
<tr>
<td>problem-based learning, project (or task)-based learning,

design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)</td>
<td>

Inspire: Children get inspired to learn, ask questions and do the research.
Research: Children learn how to research, gather insights and to create.
Children brainstorm ideas after choosing a problem to work on.
Children sketch their ideas and describe interfaces and functions with words.
Time to build a prototype! Using various materials, wheels, motors, sensors, LEDs, etc.
Children present their work and reflect - most importantly - on their experience and learnings.
</td>
</tr>
<tr>
<td>Learning objectives identified (What does this practice seek to achieve?

A change in knowledge and understanding of a scientific topic?
A change in engagement/interest in a scientific topic?
A change in attitude towards a scientific topic?
A change in behaviour related to a scientific topic?
A change in the development and/or reinforcement of skills?)
</td>
<td>
Changemaker skills,
Creative thinking,
Technological literacy,
Critical thinking,
Collaboration Skils
Visual communication
Knowledge of the Sustainable development goals
Scientific understanding of the theme they work on such as Food, Water, Mobility etc
Basic electronics
Constructing prorotypes
Presenting
Reflecting on your learnings
</td>
</tr>
</table>

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Development and/or reinforcement of skills and which ones	The experience gives children a way to co-design their futures using various technologies, and in doing so prepare them to prosper in a rapidly changing, increasing technological and complex world.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Annually, Designathon Works brings out a report on the Global Children's Designathon of that year and its outcomes. The Global Children's Designathon is the global event of Designathon Works, where children from cities all over the world simultaneously work on solutions for a specific topic related to the SDGs. For three years now, there has been a survey asking children for their thoughts and worries on the topic and what they learned. The report gives a good reflection on what has been learned and what the children feel and think about the topic and the designathon.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Worksheets, materials for building the prototype, presentation of the theme, beamer, pens, a place to build and present the prototype to the public, facilitators.
Success criteria or obstacles identified for the practice	Teachers and facilitators need to follow a training to work with the materials and the maker kits, the electronic making pieces could be an onstacle to accessing the program.
Further information can be found at: Web/Social Media/contact person, etc.	https://www.designathon.nl/

THE NETHERLANDS

Name of Existing practice	MaakPlaats 021

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A photo or logo of the practice would be nice	
Country or countries that it is applied	Amsterdam, Netherlands.
Institution (running the activity)	The Central Library of Amsterdam
Implementation year and duration (in hours, and number of sessions)	2015
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Maakplaats 021 is a network of public maker spaces in the city. The number 021 stands for the 21st century skills, skills that we need to successfully participate in a changing society. After school we offer workshops for children and young people from the neighborhood. During the day it is a workspace for schools and creatives.
Connection to school curricula (YES/ NO)	No, it is connected to schools.
Target and age groups (teachers or students)	Main focus is for primary school children ages 8-12 The Makerspaces are all located in disadvantaged neighbourhoods of Amsterdam
Location(s) (where the activity takes place)	• Makerspace in Library
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Schools, Libraries across the city of Amsterdam (10) Higher education, local cultural organisations.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning,	Schools can sign up for one of a range or programs which each take a few hours. A few exmaples are: 1. The making carousel takes students and teachers through four workshop rounds into the world of designing learning and making. 2. Making with the micro: bit: Children learn how to program themselves with the micro: bit. They learn the basics and come up with a solution for a challenging issue themselves.

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design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	3. Amsterdam designathon challenge: Children from ten primary schools in Amsterdam start designing with a self-devised solution on the theme of global citizenship Children can also come every wednesday afternoon to make whatever they want.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Creativity and digital skills. 3D printing, laser cutting and coding with a Micro: bit Learning and making
Development and/or reinforcement of skills and which ones	Empowerment by learning to make things yourself.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Not available on website, but there is a professor doing research into the creative development.

Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Maker space and Lab coaches trained in making.
Success criteria or obstacles identified for the practice	The Makerspaces are all located in disadvantaged neighbourhoods of Amsterdam
Further information can be found at: Web/Social Media/contact person, etc.	https://maakplaats021.nl

ROMANIA

Name of Existing practice	**Design for Change**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Romania, Moldova, Angola, Argentina, Bangladesh, Bhutan, Brazil, Bulgaria, China, Chile, Colombia, Danemarca, Dominican Republic, Ecuador, Egypt, France, Ghana, Hong Kong, Haiti, India, Italy, Indonesia, Ireland, Israel, Jordan, Japan, Kenya, Liberia, Lebanon, Lithuania, Macau, Madagascar, Malaysia, Malawi, Mexico, Morocco, Nepal, Netherlands, New Zealand, Nigeria, Paraguay, Palestine, Peru, Philippines, Portugal, Poland, Qatar, Saudi Arabia, Serbia, Singapore, South Africa, Spain, Syria, Taiwan, Uruguay, Uganda, USA, UAE, UK, Ukraine, Venezuela, Vietnam, Zimbabwe

Institution (running the activity)	Partnering NGOs and local schools
Implementation year and duration (in hours, and number of sessions)	2009 The program can be implemented at different levels of depth. The shortest version is 7 sessions of 45 minutes but there are also one month, and 6 months lessons plans.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Design for Change uses design thinking to help children become creative, proactive, empathetic and responsible citizen as a result of developing of an I CAN mindset. The method uses 4 steps: FEEL – empathy – nurture the heart IMAGINE- ethics – grow the head DO – excellence – use the hands collaborative action and agency SHARE – elevation – inspire hope – I can , now you can too! The teacher has the role of a facilitator. In Romania and Moldova the Design for Change partner is AllGrow.
Connection to school curricula (YES/ NO)	In some countries. In Romania and Moldova – YES but now formally
Target and age groups (teachers or students)	8 –14 years
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc. In Romania the method is facilitated by teachers during classes, after school or during the week dedicate to" Different School /Scoala Altfel". The method was used during summer camp as well to identify and implement community projects. In other countries such as Israel the method is used during birthday parties.

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Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, parents, students, local community, NGOs, local business, mentors
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	The Design for Change Methodology has 4 steps and its purpose is social oriented involving communities while fostering collaboration and solving real challenges identified by students. **Feel** - during this step students are inspired and identify a problem in their lives, communities or school they would like to address. The students gain empathy. **Imagine -** in this step students get to the root cause of the problem and brainstorm ideas. Based on their analysis they determine the solution they would like to implement which is realistic, bold and impactful. **Do –** the students put their ideas into practice and document their actions. **Share** – the project is presented at local and international level as part of the global platform. Different partners are adapting the methodology to fit local context and needs adding additional steps such as evaluation.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic?	The goals of the activities are *changes in the development of students by fostering 21st century skills* and the I CAN mindset. During the activities student also gain knowledge regarding the topic chosen and contribute to the relevant SDG.

▫ A change in the development and/or reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	21st Century skills overall Empathy, compassion, responsible citizenship, critical thinking, project organization, leadership, teamwork, communication
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	In Romania we are assessing the program with a longitudinal survey at the start and at the end of the program. We have both a children assessment and a teacher assessment happening before and after the program. In India the method was evaluated by Harvard to determine if there are any connections between the application of the 4 steps and overall school performance. The Harvard study can be seen here: https://www.dfcworld.com/SITE/Research
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	The program has a practical guide and it requires facilitators with basic understanding of the design thinking skills and facilitation skills. The programs is successful where the is an interest/ mindset towards student centered approaches.
Success criteria or obstacles identified for the practice	The program is successful where the teachers are empathetic and willing to let the students lead and play the facilitator role. Empowered teachers have empowered students.
Further information can be found at: Web/Social Media/contact person, etc.	https://www.socialchallenges.eu/en-GB/city/11/Challenges/1073#field_Description https://www.dfcworld.com/SITE

ROMANIA

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Name of Existing practice	**Fondul Științescu**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Romania
Institution (running the activity)	The Federation of Romanian Community Foundations with the support of Romanian-American Foundation (RAF)
Implementation year and duration (in hours, and number of sessions)	2015 Project teams have up to 9 months to implement their ideas.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Științescu is a movement to encourage the introduction of practical activities in the STEM education. The program provides the teachers with resources and tools to create experiments for students to learn. The program provides knowledge, resources (including financial) and support for teachers. The innovative element of this project is the framework and the funding to promote STEAM education. The teaching methods promote makers education but depend on the preferences and expertise of the participating teams, selected based on innovation, creativity, relevance and more.
Connection to school curricula (YES/ NO)	YES
Target and age groups (teachers or students)	Teachers, Librarians, ONG staff, etc. Students - 6-19 years
Location(s) (where the activity takes place)	• Community lab, FabLab, makerspace, hub, clubs, • Museum, science center, outreach center, library, zoo, etc. • Fair, contest, challenge, etc.

	The activities can take place in a wide range of spaces depending on the project proposal and may include a mix of multiple spaces.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, Mentors, Students, Local Community, Local Foundation (NGO)
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	During this project the students learn scientific theoretical concepts in a practical experimental way. The goal is to make the students familiar with the latest technologies. Students participate in do it yourself type of activities in the area of electronics, robotics, 3D printing and the introduction of technology in arts and crafts. The projects can take place in the form of science fairs, exhibitions, camps and competitions. The teaching materials combine school curricula with innovative teaching methods and student led research in the STEAM fields coupled with site visits to museums, labs and other institutions.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	The learning objectives for students is a change in the knowledge and understanding of a scientific topic as well as a change in their interest. For teachers the main learning objectives is a change in behavior related to the scientific topic.

Development and/or reinforcement of skills and which ones	Experiential learning, teamwork, initiative, curiosity towards science, critical thinking
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	The project is designed by teachers and submitted to the local community foundation. If selected the project receives funding and is implemented with students. At the end the project initiator needs to submit a project report to the community foundation.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Stiintescu provides the specific funding the project needs (within pre-defined limits). The funds are used to buy the equipment necessary for the project. The teachers/professionals who organize the workshops need to have interest and knowledges in the STEAM related fields.
Success criteria or obstacles identified for the practice	Working with local community foundations seems to be an important element to provide targeted support and monitoring. Another success criteria is to be the integration of the matching fund from Romanian American Foundation which provides additional recognition for the projects. One obstacle is the extensive period of implementation and continous engagement.
Further information can be found at: Web/Social Media/contact person, etc.	https://stiintescu.ro/ http://www.stiintescuhub.ro/

ROMANIA

Name of Existing practice	**CODE KIDS**

A photo or logo of the practice would be nice	CODE Kids
Country or countries that it is applied	Romania
Institution (running the activity)	Public Libraries
Implementation year and duration (in hours, and number of sessions)	Since 2017 Regular weekly sessions
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	CODE Kids aims to equip the students from rural area with basic coding and STEM skills in order to get involved in solving problems from their community in creative way. CODE Kids encourages student to become changemakers and start a career in technology.
Connection to school curricula (YES/ NO)	No
Target and age groups (teachers or students)	Students 10 to 14 years old from rural area
Location(s) (where the activity takes place)	• Museum, science center, outreach center, library, zoo, etc. The activities take place in public libraries
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Librarians, local community
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken:	Students learn trough a task-based approach where they receive different challenges and use coding to solve those. The program also uses experimental learning and learning though play.

problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	The project aims students development of coding and STEM skills through a change in knowledge and understanding of a scientific topic.
Development and/or reinforcement of skills and which ones	Coding skills, teamwork, critical thinking, problem solving
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	The program used for coding enables the organizers to track students' progress and development of skills.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	The project requires access to computers, specific programs and materials for making the experiments.

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Success criteria or obstacles identified for the practice	One of the challenges is the poor infrastructure of public libraries and access to computers. Another challenge is convincing librarians to become part of the project since they don t see themselves capable to work in the "IT" field.
Further information can be found at: Web/Social Media/contact person, etc.	http://www.progressfoundation.ro/en/ https://www.codekids.ro/

ROMANIA

Name of Existing practice	**Fundatia Noi Orizonturi - Impact Clubs initiative**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Romania mainly and other countries but not specified
Institution (running the activity)	Schools
Implementation year and duration (in hours, and number of sessions)	2009 During the school year the students meet for 2 hours every week inside the impact clubs
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	The IMPACT Model uses design thinking and is fostering Involvement, Motivation, Participation, Community, Teens. The program puts emphasis on the employability and social entrepreneurship for youth.

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Connection to school curricula (YES/ NO)	No
Target and age groups (teachers or students)	Teachers Students 12-18 years
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc. Inside schools there is a dedicated space for the impact club
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, Local Community
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	The activities are social purpose oriented and involving the community. The activities are facilitated by 2 leaders who are coordinating the center, usually 2 teachers from the same school.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or	The learning objective is to create change in the development of social entrepreneurship and community involvement.

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reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	Teamwork, empathy, creativity, critical thinking
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	They are assessing the performance though regular evaluation and the coordinating teachers who are overseeing the centers along the duration of the program.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	The project requires teachers training, guidebooks and space for conducting the activities. It also requires a support and coordination team who coordinates and coaches' teachers.
Success criteria or obstacles identified for the practice	The project has well designed attractive materials and the organization has a strong operational structure.
Further information can be found at: Web/Social Media/contact person, etc.	https://www.noi-orizonturi.ro/tineri/cluburile-impact/

ROMANIA

Name of Existing practice	Kogaion Academy
A photo or logo of the practice would be nice	
Country or countries that it is applied	Romania

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Institution (running the activity)	Kogaion Academy
Implementation year and duration (in hours, and number of sessions)	Since 2013 13 sessions or during the summer vacation
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Kogaion Gifted Academy supports the development needs of students at different ages based on their development needs with the goal to increase their areas of knowledge, development of competencies and skills.
Connection to school curricula (YES/ NO)	No
Target and age groups (teachers or students)	Students 3-16
Location(s) (where the activity takes place)	• Community lab, FabLab, etc.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, Parents
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	The program uses a mix of learning methods combining collaborative and task-based learning.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and	A change in knowledge and understanding of a scientific topic. The Academy has different tracks such as: • Technology Advance Learning • Visual Advance Learning

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understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	• Science Advance Learning And a series of summer schools focused on different topics.
Development and/or reinforcement of skills and which ones	Development of STEM, life and media skills
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Assessment takes place along with the duration of the programme.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	LEGO toolkits, robotic guides, projectors, volunteers and spaces for activities, Phyton, ArchiCAD, Photoshop/GIMP,
Success criteria or obstacles identified for the practice	The team is reputable and has a wide range of courses. Participants needs to pay for classes and are available both during the school year and in the form of Summer Camps.
Further information can be found at: Web/Social Media/contact person, etc.	http://kogaionacademy.ro/

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Practices applied on a European and world wide level

Name of Existing practice	**Playful Robotics Workshop (PlayRobs)**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Germany
Institution (running the activity)	School Student Research Center (in German: Schülerforschungszentrum) of the Technical University of Munich in Berchtesgaden
Implementation year and duration (in hours, and number of sessions)	2018-2020, during the holidays 3-day workshop with 9 hours in total.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Playful Robotics Workshop (PlayRobs) is an extracurricular course that takes part during the holidays in a voluntary frame. The School Student Research Center have many innovative courses, helping its students to develop their own projects and raise interest in STEM education. PlayRobs is a workshop of three days, where the students try to learn basic programming skills and help their robots to solve different problems, creating a real application of their idea.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Students of primary school (7-to-12-years old).
Location(s) (where the activity takes place)	The workshop takes place in a properly designed room of a former school building.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	One facilitator is present during the learning session, helping and encouraging the students with their projects.

Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Ten children attend every course, creating a friendly atmosphere, while they are working in dyads. At the first stage, an initial introduction is taking place and the students fill in a questionnaire about their understanding of coding. At the next stage, each group of two children takes time to think and build their own functioning LEGO Mindstorms EV3 basic robots, as it helps them to better understand the different sensors and components, as they will use them later in the robots' construction. After the introduction, the students take a booklet with exercises of eight tasks for programming their robot. These tasks describe different situations/problems with matching algorithmic structure, like sequence, and loops. The students can work on these tasks the rest of the first day and the whole second day, and they can write code and test it on the robot. At the same time, they can all share their ideas in order to exchange inspiration. On the third day, they develop their project in a real application of a robot, by combining everything that they have learned. Finally, they present their ideas share their experiences.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Students through the PlayRobs workshop can gain basic knowledge in coding and programming. They can try several coding experiments as the can write code and test it in a real time. The workshop is based on three learning procedures: making, as they develop their own self-designed devices, coding, as they write code for their robots, and playing, as the workshop is playful and friendly, and they are working in small teams. Through the maker education which characterized the PlayRobs workshop, children can ensure their confidence to explore their ideas, as they are confronted with technical constructions and programming.
Development and/or reinforcement of skills and which ones	Children learn how to work together closely with another child, having a challenging project to build a robot, which is a demanding and time-consuming procedure. They interact through various self-assembled physical tasks, while through them, they can learn engineering

	disciplines, how to use different sensors for measuring quantities like temperature and color. Furthermore, the most important skills are those of the exploration of the core computer concepts, as the build algorithms that are able to control the whole system. In this way, the students develop important skills of the 21st-century, as all of PlayRobs aspects are based on modern science.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	A questionnaire at the beginning of the workshop is given to the students in order to assess their possible knowledge in programming. At the end of each day feedback from all students is collected. At the end of the workshop, a questionnaire is handed to the students in order to complete at home and return it back.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	No or only a minimum of previous experience in coding. The language of the workshop is German. However, the PlayRobs has no other prerequisite nor required prior knowledge. On the other hand, various instruments, materials and equipment are required. The materials are a LEGO Mindstorms EV3 Core Set, the corresponding software that is installed on a Microsoft Surface Tablet, a number of floor tiles and a blackboard, an exercise book, an exercise book, various (driving) pads/mats, big LEGO blocks, screens and audio, short surveys, etc.
Success criteria or obstacles identified for the practice	Already 115 students from different schools have participated, with 87 students in nine PlayRobs workshops, plus 28 students that attended a different course and helped as a control group. While the workshop it is a quite interesting learning procedure, it might be difficult to be implemented into the formal curriculum, due to the expensive equipment that is needed.
Further information can be found at: Web/Social Media/contact person, etc.	https://schuelerforschungszentren.de/

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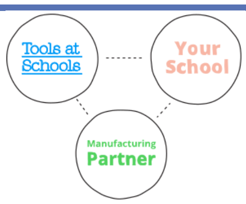
Name of Existing practice	**Tools at Schools**
A photo or logo of the practice would be nice	
Country or countries that it is applied	USA
Institution (running the activity)	Tools at Schools
Implementation year and duration (in hours, and number of sessions)	From 2009 A 6-month program
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Tools at Schools is a collaboration between a school and a corporation in order to help children understand the process of design thinking and its value as a tool for problem-solving. Its structure is designed for children by children. It takes place at schools, and the students follow the entire process of design thinking, from research and ideation to 3D modeling and their final prototype, while at the same time they utilize their math, science and communication skills to fully thought-out solutions. They also focus on familiar products and problems of the everyday life and students can observe their ideas come to life on the real world.
Connection to school curricula (YES/ NO)	YES
Target and age groups (teachers or students)	Students
Location(s) (where the activity takes place)	• Classrooms

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Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	The team of the Tools at Schools is the leader of its project and every school is taking part with its students, while a company is taking part in order to create a target for the product design.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	At the first stage of the program, the main values and the process of design thinking is being proposed to the students, while they are being encouraged to think about solutions to problems of the real world. On the 6th week, students try to search for available similar products and identify the possible situations in which their products could be used as well as the audience that will be interested in them. On the 12th week, students develop their ideas into models, as they visualize them in sketches and model formats. Fixing their mistakes, they make their models stronger. They also present their models to a panel of experts. On the 14th week, the most collective ideas are identified, and the students create their 3D models. On the 25th week, the Bernhardt Design team, from the North Carolina manufacturing facility, is testing the models and they test the materials and colors to create the final prototypes, where the students can visit the factory to see the whole process. At the final day, the students present their prototypes to the faculty, their families and friends, while they describe their experiences.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or	Through this program, students are able to learn how they can find real solutions to several situations of their everyday life or they can design and create their own products. As every program that lasts 6 months is quite different, students have the opportunity to create unique approaches to the situation that is being examined every time. They can learn many scientific aspects of a problem or a situation. For instance, they can explore how to transform their classrooms and the learning processes, by testing innovative ways of learning or using scientific tools for help at their courses. At the same time, in the case of a product's design, they can learn the real way of the product's design and production process.

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reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	As the students work on teams for six months, they develop deeply their communication and cooperative skills. Furthermore, existing friendships are made stronger by collaboration and goal setting, and new friendships can also be easily developed. The students, through the program, try to utilize their knowledge on science and math, while they are learning new aspects of them, too.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	There is no given information about the assessment procedure of the program.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	There is no need for certain required knowledge by the students. The most important point about the program is the need of a company that will help to create a real product.
Success criteria or obstacles identified for the practice	Tools at Schools have succeeded in many projects, like the following three examples: • Designing the Sneaker for the Future, in which the students designed their own real sneakers. • Innovation Education at Marymount, where the students created an innovative culture inside the classroom, with fun, new tools and creative ways of learning. • Innovation Education at Marymount School of New York, where the students designed their own innovative procedures for homework, lunch, grading and discipline. • The Year of Innovation at The School at Columbia University
Further information can be found at: Web/Social Media/contact person, etc.	http://www.tools-at-schools.com/

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Name of Existing practice	**Happiness Makers Workshops**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Singapore
Institution (running the activity)	Happiness Makers
Implementation year and duration (in hours, and number of sessions)	3 types of workshops (maximum 20 children): 1. Creative Confidence Workshop • 12 hours • 2 separate learning days 2. Creative Confidence Workshop (Upsize) • 7 hours 3. Creative Confidence Workshop (Bitesize) • 3 hours The student has to attend the previous workshop before proceeding to the next workshop.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Happiness makers is an organization that aims to create a learning environment based on important job skills that young people should have in order to be independent and able to think out of the box. Through their activities, the kids from an early stage can learn how to act like solvers of difficult problems, to take risks and to create visions.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Children and teens between 9-to-14-years-old

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Location(s) (where the activity takes place)	The workshops can take place in classroom on the weekends, and they also have organized workshops in learning institutions.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Their facilitators and the teachers form schools.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	The first-stage workshop has some introductory details for the design thinking, the second-stage workshop has some additional procedures, and the third-stage workshop has a complete procedure of the design thinking and making. Thus, we will explore here the third-stage workshop. Their program starts with an introduction to the design thinking process to understand its human-centric values, develop their empathy and comprehension for a problem. After that, they try to find the user needs and desires through field work training, starting the journey mapping and turning their ideas into statements, and they generate innovative concepts. Subsequently, the children have brainstorming sessions, and they understand the importance of prototyping. They have field work training, and they proceed to prototyping and they create a presentation of their ideas, while they have again brainstorming sessions. Finally, they build their models and the present them to the others.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Their program is designed with reference from the WSQ National Competency Standard, a national credentialing system of Singapore with workforce skills qualifications. Children learn a step-by-step guide to exploring their creativity, having a human-center approach for finding solutions in difficult situations. Their workshops are not clearly scientific, but processes are focus on making. They teach children how to communicate through a team's interactions, foster their creativity, and align them to specific targets and results. In general, they create a stimulating environment in which the students can learn through playing, making and valuable participation in order to explore their protentional.

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Development and/or reinforcement of skills and which ones	The children can gain many important skills through those workshops. They enhance communication and observation skills, empathy, curiosity, and imagination. The workshops align children in specific targets and results, while they explore a problem deeply. Moreover, they boost their confidence in expressing their opinions, and they learn how not to be sensitive to criticism, but to welcome it as an opportunity. Students also try to discover opportunities that not everyone can see, and they search for valuable problems to solve. Through creativity, children learn how to be more active and braver, facing a failure as a chance to try harder and move forward.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	No assessment tactics are mentioned during the workshops or at the end of them.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	No previous knowledge is required. The workshops need to be equipped with stationery and equipment for children's constructions.
Success criteria or obstacles identified for the practice	They do not publish the numbers of the children that have participated in their workshops, but they have already run many creative workshops in schools, and other organizations.
Further information can be found at: Web/Social Media/contact person, etc.	https://www.happinessmakers.com/

Name of Existing practice	**Maker@Scuola**

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A photo or logo of the practice would be nice	
Country or countries that it is applied	Italy
Institution (running the activity)	INDIRE
Implementation year and duration (in hours, and number of sessions)	2014
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	The Maker@Scula project is based on the learning model designed by the “Movement Maker” and it is applied on laboratory teaching schools. The project targets to overcome the traditional teaching methods and to support an inventory way of teaching and learning, while the students are being protagonists of the whole process.
Connection to school curricula (YES/ NO)	YES
Target and age groups (teachers or students)	Children, from kindergartens to high schools
Location(s) (where the activity takes place)	Inside the classrooms
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	INDIRE researchers and teachers
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning,	The project has several training sessions and it promotes the re-use of things, the optimization of procedures and resources and a positive way to solve problems. Among the training sessions, the student can design their own products, and thus they can synchronize the requirements of the real world with the environment of their school. In general, the program is based on three aspects of the design tginking cycle; think, make and improve. The aspect of thinking includes problem setting, brainstorming sharing and design. The aspect of making includes logical thinking, discussion and meditation, modeling and prototyping. And

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design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	the aspect of improving includes observation, verification, the importance of mistakes and improvement. Its procedures are characterized by a *Tinker-ing* methodology, a philosophy of *Share-ing* and a *Haker-ing* approach. The *Tinker-ing* methodology is based on the Think-Make-Improve design thinking cycle that has a stage of conception, a phase recognition of a problem and a final stage of solution and improvement. The philosophy of *Share-ing* helps the students to collaborate and share their knowledge with the others with responsibility and social self-regulation. The *Haker-ing* approach tries to analyze every process, by breaking it down in small steps and putting them back again while the students can use new knowledge to create innovative things.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	The Maker@Scuola aims at the analyzation of the characteristics of design and making and understanding its specific parts, featuring many aspects of learning methods. They try to apply new innovative tools and creative educational models that are aligned with many scientific aspects. Especially, they focus on several mathematical skills, as the students learn how to learn and apply mathematics in practice. Furthermore, as they have many projects, like for example 3D programmes, where the students learn how to model and optimize the 3D printing process, while they are using online environments with useful tools. Thus, children learn many technical and technological skills, with the help of science and mathematics. In addition, a part of the project is the hydroponic greenhouse at school, in which the students observe and study a real greenhouse, introducing the scientific method inside the school.
Development and/or reinforcement of skills and which ones	Through the Maker@Scuola project, the students can develop important scientific, mathematical, linguistic and relational skills, as well as meta-skills and soft skills. They are encouraged to participate more in several learning activities, and they feel that they belong to a team with a purpose and meaning. The students have the chance to apply their ideas, skills and knowledge into practice. Furthermore, children develop their logical thinking and their abilities for problem solving.
The Assessment/ Reflection of the learning objectives	Schools try to assess every program with observation grids, evaluation sheets and a work diary in order to observe the learning processes. Moreover, schools take part in many

(Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	webinars and online communities, there the students consolidate their knowledge.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	As we can see, the Maker@Scuola has many requirements in order to be applied in a school. The students do not need to have certain knowledge before the programmes, but many supporting materials are required. Information and downloadable manuals are quite important to support every program. 3D printers and software also are required for the respective project, and as well as the conditions, space and equipment to create a greenhouse. However, prost of the materials are provided by the organization, and the schools need only to have a 3D printer, access to the Internet, an interactive whiteboard or a computer.
Success criteria or obstacles identified for the practice	Since the launch of the Maker@Scuola programs, many schools have been involved, with over a hundred schools, including primary and kindergarten students. Thus, the project takes place in more and more schools, with a large number of students in their programs.
Further information can be found at: Web/Social Media/contact person, etc.	http://www.indire.it/progetto/maker-a-scuola/ http://www.indire.it/wp-content/uploads/2015/09/MAK-1605-Brochure_VX_ING-3.pdf

Name of Existing practice	**Activista I CAN**

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A photo or logo of the practice would be nice	
Country or countries that it is applied	Spain
Institution (running the activity)	Design for Change Spain
Implementation year and duration (in hours, and number of sessions)	2 to 4 hours
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	The main aim of the Activista I CAN is to support the children to be change agents in their own communities. The workshop follows the values and the procedure of design thinking and it has five different stages, starting from the generation of the ideas, to prototyping, and taking steps towards action, while they communicate the results to the others. Its vision is to lead children to develop critical thinking skills, creativity, communication and collaborative skills, and shared leadership. It is a workshop with a non-formal way of learning and the language was Spanish.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Secondary school students, from 15 to 16 years old (in the first workshop) and from 12 to 13 years old (in the second workshop).
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc. The workshop in Barcelona took place at a building of a university and the workshop in Madrid at a multi-purpose room of a school.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	A facilitator can work with many teams at the same time, as every team works on its own, following the instructions of the provided videos. Thus, in every workshop was only one facilitator. Many teachers were also there to help.

Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	One workshop took place in Barcelona with 90 children from different schools. A second workshop took place in Madrid with 70 students. Every workshop was an extracurricular activity. They created small groups of 7 to 8 students in every group. Every workshop had five steps: 1. Feel. Students try to identify problems that could search for solutions, while they try to emphasize on empathy. 2. Imagine. Students try to be positive about facing a problem or a situation, while they have brainstorming sessions, and they choose among the available solutions. 3. Do. Here, they are being active by testing their ideas into action, through making methods. 4. Evolve. Students here try to understand deeply their experience with self-reflection. 5. Share. And finally, they share their results, experiences and emotions with the others.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	All the participants understood that the science in general plays a quite important role on their everyday lives. The workshops supported the children to work on their own scientific projects, and at the same time they learnt the scientific side of the citizenship. Moreover, the workshop aimed to teach to the students several fields of science, which can influence them by leading them to various career options.
Development and/or reinforcement of skills and which ones	Through the Activista I CAN workshop several skills were developed. In the whole process, the facilitator was encouraging the members of every team to work together, promoting a productive interaction through empowerment. Thus, it was observed that children work

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	closely in order to achieve a common goal, supporting friendships and creating new ones. Furthermore, listening and communication skills, and as well as creativity and critical thinking were supported. Students were highly motivated to learn new things and be more active.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	During the workshops, the facilitators and the teachers were identifying the learning procedure and at the end of the workshops, all the participants answered a questionnaire.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	No specific knowledge was required. Participants were provided with videos and they follow instructions, thus an electronic device was needed for every team. Every team had stationery, like pens, crayons, and papers, as the workshop included many design and making activities.
Success criteria or obstacles identified for the practice	90 students participated in the first workshop and 70 in the second workshop. Apart from them, they continue to organize Activista I CAN workshops in many cities around the Europe. They aim to create the right conditions for the change to occur and all their processes are based on Design Thinking. Also, The United Nations recognizes the Design for Change organization as one of the promoters of the Sustainable Development Goals (SDGs).
Further information can be found at: Web/Social Media/contact person, etc.	https://www.dfcspain.org/

Name of Existing practice	**Future Designers**

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A photo or logo of the practice would be nice	 
Country or countries that it is applied	Greece
Institution (running the activity)	Institute of Computer Science – FORTH
Implementation year and duration (in hours, and number of sessions)	In 2015. Tested through four pilot sessions. Each session of the Future Designers course lasts four hours.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Future Designers is a four-hour interactive crash course that aims to introduce primary school children to the concepts and practice of creativity, design, and design thinking. on. Future Designers takes a holistic approach, where children are introduced to the broader context of design and its impact on our everyday lives, as well as to the notion and practices of design thinking. The course mixes multiple learning styles and intelligences through diverse teaching and learning approaches and multimodal digital material.

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	The course is structured as follows: Introduction, Overview, Team Quiz Game, Travel to the Future, Design and designers, Activity 1 (Individual): Designer for a while (The spoon), Imagination and creativity, Activity 2 (individual): What makes me dream?, Design errors and assessment, Imagination and fun, Prototyping, Activity 3 (team): The marshmallow challenge, Two Magical Phrases, The five uses of a designer's pillow, Activity 4 (team): Inventing for my school, and the Future Designer Diplomas award ceremony.
Connection to school curricula (YES/ NO)	Not directly
Target and age groups (teachers or students)	10 – 15 years
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc. Future Designers follows a learner-centred design approach, in the context of which the course is being iteratively evaluated and tested in real settings with representative stakeholders through pilot studies with complementary characteristics and goals. Up to now, the course has been tested in **5 different pilots, four of which in real school settings.** All pilots were followed by two observers taking notes and pictures, and collecting spontaneous feedback. In pilots 3 and 4 user satisfaction questionnaires were also used.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Primary school teachers, post-graduate students, students (10 to 12 years old), parents.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social	Learner-centered Design-based learning

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purpose oriented, involving families/ communities)	
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	▫ Initiate children to a way of thinking and skill which can enhance learning, solve everyday problems and improve future employment prospects and quality of work. ▫ Empower, boost self-confidence, inspire and spark imagination. ▫ Help children discover and acknowledge their ability to imagine, create and have ideas of value of their own. ▫ Deliver a memorable and fun intellectual and emotional experience. ▫ Encourage collaboration among children, children and teachers, as well as children and parents. ▫ Sow the first seeds towards the creation of 'micro-communities' that are supportive and rewarding of creativity. ▫ Provide feedback to the scientific community about how children perceive contemporary technologies and design.
Development and/or reinforcement of skills and which ones	Creativity.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	During the past year, the course has been tested and validated in Greece through four pilots: (i) at the facilities of ICS-FORTH, with eight primary school teachers, four post-graduate students and two children; (ii) in a real classroom with 22 children 10 to 12 years old; (iii) in a classroom environment with 25 primary school teachers assuming the role of children; (iv) in a classroom with 17 children (10 years old) and their parents (15 people). Observation and questionnaire evaluation data converge on the fact that the course achieves its original goals and constitutes an engaging and enjoyable experience, as well as a successful means of introducing and provoking creativity and (design) thinking. Despite its length and high mental and physical demands, when it ends, participants report feeling happy, motivated, and full of positive energy. The participating children's average evaluation score for the course was 9.7/10, while their parents was 8.8/10, and

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	both groups unanimously agree that Future Designers works as an effective communication tool and a compelling topic of discussion among children and their parents and friends.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	**Materials:** Bucket. Rubber ball. Colored, pens, paper, plasticine. Post-its. Photos of old designs (from 1900's). Marshmallow challenge per team: one marshmallow, 20 sticks of uncooked spaghetti and 10 pieces of string. Pillows. Materials for making. **Templates:** Invention declaration form and Future Designer Diploma. **Knowledge:** being able to lead discussion on past, present, future society. Being able to lead discussion on what a designer is, e.g. with examples of design history or designers in different domains (Daedalus, Archimedes, Gutenberg, da Vinci, Scappi, Shakespeare, Bach, Levi Strauss, Gaudi, Tesla, the Wright brothers, Coco Chanel, the Beatles, and Steve Jobs). Knowledge about design basics.
Success criteria or obstacles identified for the practice	The crash course has proved in practice to be a very engaging and fun experience, both for children and adults. Furthermore, it has achieved to raise interest in personal and social creativity and innovation. Despite its length and high mental and physical demands, when it ends participants (including the organizers) feel happy, motivated and full of positive energy. Stated levels of satisfaction and fun are very high for participants of all ages.
Further information can be found at: Web/Social Media/contact person, etc.	http://delivery.acm.org/10.1145/2850000/2846695/p58-grammenos.pdf?ip=131.155.41.240&id=2846695&acc=ACTIVE%20SERVICE&key=0C390721DC3021FF%2EECCBF8AC29DF345E%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&__acm__=1575911816_06fb79fcacc9ef269ada441d97cc40b1

Name of Existing practice	Ready, Set, Design

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A photo or logo of the practice would be nice	
Country or countries that it is applied	USA (New York)
Institution (running the activity)	Cooper Hewitt, Smithsonian Design Museum
Implementation year and duration (in hours, and number of sessions)	On-Going since 2011. Quick design activity: 30 minutes to 45 minutes.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Ready, Set, Design is a quick group activity. It uses simple, inexpensive materials and is an effective tool for problem solving, creative thinking and team building. Ready, Set, Design is not just for designers but can be used by any audience as a way to engage in design thinking. Participants are asked to solve an open-ended problem with time and material constraints. Working in small groups, solutions are developed quickly and yield surprising solutions that may not have been immediately obvious.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Museum visitors interested in Design Thinking

Location(s) (where the activity takes place)	• Community lab, FabLab, etc. • Museum, science centre, outreach centre, library, zoo, etc. It is hosted by the Cooper-Hewitt design museum, but it can be done everywhere where people come together and as a quick design/creative activity.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Museum hosts, students. Can include: parents and teachers.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Task-based learning
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	Change in attitude: other way of seeing materials and creativity.

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Development and/or reinforcement of skills and which ones	Creativity
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	-
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	**Materials:** - Paper lunch bags - Challenge cards (can be a slip of paper or an index card) - Fastener items (for example, pipe cleaners, rubber bands, paper clips, string) - Surface items (for example, coffee filters, carboard squares, balloons, paper) - Structure items (for example, straws, tongue depressors, wood skewers, tin foil)
Success criteria or obstacles identified for the practice	-
Further information can be found at: Web/Social Media/contact person, etc.	https://www.cooperhewitt.org/2011/09/09/ready-set-design/

Name of Existing practice	**Taking Design Thinking to Schools Project**
A photo or logo of the practice would be nice	REDlab Research in Education & Design

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Country or countries that it is applied	USA, Palo Alto, California
Institution (running the activity)	Taking Design Thinking to School is a collaboration of the Hasso Plattner Institute of Design (d.school, part of Stanford University), the School of Education (SUSE) and teachers in local schools to explore how design thinking can best impact teaching and learning.
Implementation year and duration (in hours, and number of sessions)	The project spanned a threeweek period. Sessions occurred twice a week during a two-hour period for a total of 12 hours of classroom time.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	The purpose of the Taking Design Thinking to Schools Research Project was to extend the knowledge base that contributes to an improved understanding of the role of design thinking in K12 classrooms. The instructional goal of the project was to use design thinking to teach students about systems, an important element of geography. Students, who worked in collaborative teams, were guided through the design process to identify and redesign systems that existed at the school. The teaching team, which included four 'instructors' and five 'coaches', had a meeting at the start of each week to plan the lessons. Once the lesson plan was complete, the entire teaching team reviewed it, adding changes where necessary. Students groups consisted of four to five students. Every class session included two instructors and three coaches; therefore, each group had a design coach to assist them. The sessions alternated between direct instruction by members of the teaching team and group work on the design projects. The instructional tasks for the design units focused on introducing students both to the design process and to systems in geography. The instructors used a variety of strategies. These included whole-class instruction, class discussions, modelling, hands-on activities, small group work, brainstorming and individual instruction.
Connection to school curricula (YES/ NO)	YES
Target and age groups (teachers or students)	The school site for the research project was located in a semi-urban setting in the San Francisco Bay area. There were approximately 215 students in the public charter school, which has classes in grades K-3 and 6 and 7 and adds new grade levels each year.

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	The study participants included a seventh grade class of 24 students, their teacher, two university design school staff members, two graduate student instructors, and graduate students who were small-group coaches. Two post-project interviews of classroom teachers who had previously completed a design unit were also interviewed to better depict teachers' views of design in the school curriculum.
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, Instructors, Students, Researchers
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Project-based learning
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic?	A focus on innovation, creativity, critical thinking, problem solving, communication and collaboration is essential to prepare students for the future. Passig (2007) describes the skill of melioration, which he considers essential to successfully functioning in the twenty-first century, as choosing the appropriate chunks of information, and applying them to the solution of problems in different time and space-dependent situations. Challenging students to find answers to complex and difficult problems that have multiple viable solutions and by *fostering students' ability to act as change agents.*

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▫ A change in the development and/or reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	Creativity and problem-solving.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	Explorative/Qualitative research. No Assessment of learning outcomes was directly done. Reflections on practice was done in three themes: **Design as Exploring:** - Students displayed diverse understandings of the design process. - Students appropriated design discourse in varied ways. - Students created projects that expressed their understanding of design thinking principles, - Design thinking can be a tool that fosters metacognition. **Design as Affect:** - Students showed positive affect while engaging in design thinking activities. - Students engaged in collaborative learning while participating in design thinking activities. - Students preferred active learning activities to passive listening activities. - Design thinking projects facilitated engagement by providing an opportunity for students to express their voices and opinions. - Prototyping can be a powerful classroom tool to engage students quickly and does not focus on perfection. **Design as Intersection: Design Thinking & Content Learning**

	- Creating a classroom design project that integrates academic standards, content learning and design thinking is a challenging process. - Students made tenuous connections between design thinking and academic learning.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Knowledge and information on the project-theme. Knowledge of Design Thinking. Materials for rapid prototyping. Movie making tools: camera's/phones, laptops with software. Beamer to show movie.
Success criteria or obstacles identified for the practice	First, and foremost, the function of design thinking should be to enhance classroom instruction. This must be done by learning what the teachers' instructional goals are and using design thinking to support student learning. A supportive relationship between the teacher and the classroom instructor with clear communication of goals is essential. Teachers need to see the value of the design thinking process and how it can help them with their students. Second, design thinking must be integrated into academic content. While it may stand alone, its power as a tool for learning comes in the ways it can support a diverse range of interdisciplinary academic content. Design curriculum requires strategic integration of education standards, design principles and content information. This means it is critical to focus on creating activities that teach the fundamental mindsets and processes of design thinking and are entwined with content learning. Classroom experiences need to provide spaces where students to have 'what if', 'what could be' and 'what might happen' experiences (Wong 2007). Teachers face a struggle to teach students all they need to learn, and if they are asked to integrate design thinking into their classrooms it needs to be done in a way that synergizes instruction that is already in place. Third, design thinking has an impact on the ways that students engage in the learning process. It challenges them to think in new ways and take risks. Design tasks must focus on harnessing that engagement, and supporting students as they prototype, fail, and prototype again. Failure, as it is

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	traditionally defined in the classroom, must be reconceptualised. Fourth, design thinking and collaboration are intricately linked. The collaborative process in the classroom is impacted by students' willingness to listen to other's ideas, to take risks and to share their ideas with others. Carroll (2004) describes how collaboration involves creating a classroom climate where others' knowledge is valued and is both modelled by the instructor and becomes an essential part of the classroom culture. Design thinking projects thrive in a climate where collaboration is an explicitly valued part of the classroom culture. Fifth, design thinking provides a means for students to be cognizant of where they are in the process, and encourages metacognitive awareness. Design thinking activities should focus on how to best foster this awareness through both the design cycle and in assessment of academic content learning. Sixth, design projects and design discourse practices can provide new ways of thinking that can be incorporated both into teachers' classroom instructional strategies and students' approaches to learning.
Further information can be found at: Web/Social Media/contact person, etc.	https://web.stanford.edu/group/redlab/cgi-bin/publications_resources.php https://web.stanford.edu/group/redlab/cgi-bin/materials/IJADE_Article.pdf

Name of Existing practice	**FabLearn (FabLearn Labs, FabLearn Conferences, FabLearn Fellows)** **(Case study of FabLab@SCHOOL.dk)**

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A photo or logo of the practice would be nice	FABLEARN FAB LAB @SCHOOLdk Part of the global FabLab@SCHOOL
Country or countries that it is applied	**FabLearn:** From the USA, worldwide conferences, fellows, and research groups. **FabLab@SCHOOL.dk:** Denmark, Aarhus, Aarhus Universitet.
Institution (running the activity)	**FabLearn:** Transformative Learning Technologies Lab, Teachers College, Columbia University. **FabLab@SCHOOLdk:** Child-Computer Interaction Group, Aarhus Universitet.
Implementation year and duration (in hours, and number of sessions)	**FabLearn:** unknown **FabLab@SCHOOLdk:** On-going since 2014
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	**FabLearn** disseminates ideas, best practices and resources to support an international community of educators, researchers and policy makers committed to integrating the principles of educational makerspaces and constructionist learning into formal and informal K-12 education. **FabLab@SCHOOLdk** is an educational initiative providing research-based, innovative education to primary and secondary school students as well as teacher training and a network, where teachers, pedagogues, and school leaders can find inspiration for working with design thinking, digital fabrication, and 21st century skills. The initiative aims to develop new teaching concepts for project-based, studentcentered, hands-on learning, and for creating and developing FabLabs as hybrid learning environments. Inspired by the work of the global FabLearn network and CAVI at Aarhus University, FabLab@SCHOOLdk offers FabLab learning activities that give children the opportunity to develop their

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	understanding of technologies through examining, testing, and designing technological objects in a digital fabrication laboratory. The activities and the real working environment with its high-tech machines provide new ways of inspiring, familiarizing, and equipping students with some of the skills and competencies considered to be crucial in the 21st century, such as critical thinking, communication and collaboration, digital citizenship, design, innovation, mastering technologies, and complex problem solving. In this context FabLab@SCHOOLdk aims to make the students see themselves as problem solvers, who not only use technologies, but also think about technology and apply it for problem solving in their everyday lives.
Connection to school curricula (YES/ NO)	YES
Target and age groups (teachers or students)	Teachers, e.g. through the FabLearn Teacher Pioneer network and Schools.
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc. Aim to embed FabLab concept into schools
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	**FabLearn:** Educators, researchers, school boards/staff, and policy makers foremost. Indirectly: students, parents. **FabLab@SCHOOLdk:** The study has identified five important stakeholders supporting these processes: 1) Pioneer Teachers, who are key actors in developing teaching practices, including FabLab learning activities; 2) School Leaders, who hold a crucial position with regard to developing strategies for supporting teachers in this context; 3) FabLab Leaders, who provide and develop expertise within technology and pedagogy; 4) Project Leaders, who support the work of FabLab Leaders and develop meaning in the educational organizations; and 5) the FabLab@SCHOOLdk organization, which supports and facilitates internal and external collaboration.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken:	Constructionist learning

problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behavior related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	**FabLearn:** We believe hands-on learning should be: - **Personal:** Student-led projects are examples of curiosity-driven, self-directed, creative learning: the type of learning that is personal, engaging and motivating. Student passions and interests translate into the most successful learning opportunities. - **Meaningful:** Learning is effective when it is meaningful and relevant. The best project-based learning occurs when it is based on real-life problems or focuses on open-ended challenges. If knowledge is sought out when it is needed, it is relevant to the student and the student's project. - **Cross-curricular:** Learning should be interdisciplinary, just like the real world is. While fabrication is most easily associated with STEAM subjects, it can also be successfully integrated into projects in other disciplines, including the humanities. - **Holistic:** Learning should not be focused singularly on curricular content or technical knowledge. Cognitive and soft skills such as creative and critical thinking, teamwork, communication and project management are also crucial, as is learning how to think like a designer, a scientist, an engineer, an artist, a computer scientist, etc. - **Process-oriented and product-oriented:** Learning should be assessed not just based on the final product, but also on the process that led to it. - **Modeled by teachers:** Learning is not restricted to students. Teachers should embrace and model constructionist learning and maker education, learning alongside students, and looking for balance between guidance and autonomy. **FabLab@SCHOOLdk:** They aim to empower teachers to give their students the competencies and skills necessary in the 21st century,

	to involve and prompt School Leaders to support teachers in their work, and to help schools build their own FabLabs to offer FabLab activities to everyone.
Development and/or reinforcement of skills and which ones	Students making skills.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	**FabLab@SCHOOLdk:** In a case study of the Danish FabLearn division (formerly: FabLab@SCHOOL.dk): The study can be characterized as a case study using ethnographic methods and conducted through enrolment in the Danish network and societies of FabLab@SCHOOLdk in the three partnership municipalities Silkeborg, Vejle, and Kolding. The field study lasted five months and the objective was to learn from the experiences of the partners and thus reach an in-depth understanding of how the initiative operates. First, the study investigates different approaches to educating FabLab Pioneer Teachers and presents main similarities and differences between the partnership communities across the three municipalities. The data is collected through physical presence, participative observation, and engagement in Pioneer Teachers' communities, and it is represented in e.g. photographs and notes on many aspects of the Teachers' and School Leaders' everyday practices and processes as part of the FabLab@SCHOOLdk educational programs. Second, the study examines FabLab@SCHOOLdk and the work of FabLab Leaders, FabLab Learning Supervisors (together the 'FabLab Team'), Project Leaders, and National Coordinator by investigating their daily efforts to design, organize, and implement training of Pioneer Teachers. Furthermore, in order to gain insight into relevant stakeholders' experiences with and perspectives on FabLab@SCHOOLdk educational programs, two questionnaire surveys were carried out: one among school teachers and teacher training college educators (N=17, referred to collectively as 'Teachers') and another among School Leaders, FabLab Leaders, and FabLab Project Leaders (N=16, referred to collectively as 'leaders'). The questionnaires, containing both fixed-choice and open-ended questions, investigate how the FabLab@SCHOOLdk initiative has prepared teachers for initiating learning activities involving design thinking and digital fabrication, and it sheds light on what still seems to be missing for implementing such activities at school.

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Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	**High investment.** The creation of a FabLab within a school. Knowledge about machinery, tools, safety, design, making, and teaching related skills, attitudes, and knowledge. Human resources for the day-to-day operation and repairs of machinery and Lab. Development of related learning/teaching materials.
Success criteria or obstacles identified for the practice	**FabLab@SCHOOLdk:** The insufficient capabilities of teachers when teaching digital fabrication and design processes have been defined as: 1) understanding complex design processes, 2) managing digital technologies and design materials, and 3) balancing different forms of teaching. The framework that can be used to educate teachers in these subjects suggests combining 1) theory-based lectures and workshops in design and digital fabrication, 2) peer-to-peer-collaboration and reflections, and 3) in-school practice. Curiosity, open-mindedness, generosity with regard to sharing knowledge and skills, project- and problem-based practice, and willingness to develop traditional educational practices are emphasized by all the stakeholders as necessary for developing and implementing FabLab activities and for acquiring the competencies for doing so. The roles and tasks of the different stakeholders seem to interact and establish an organism, where no one can be removed without disturbing or destroying the progress. The role of the Project Leaders is twofold: They prime School Leaders by setting the agenda, providing them with knowledge and networks, and helping them to develop commitment to and ownership of the FabLab activities in their local schools. But they are also responsible for establishing a framework for the central FabLab and the work of the FabLab Leaders, providing resources, backing, and publicity. The Pioneer Teachers depend both on the expertise support of the FabLab Leaders and professional FabLab network and on the active support of their School Leaders for carrying out FabLab activities in the local schools. It seems valuable to underline that progress in the current case does not seem to arise only from financial investment in technologies, but also from conscious and substantial investment in the development of a shared mindset, network activities, education, time for immersion, and resources for implementation. The findings emphasize that FabLab@SCHOOLdk is not about the FabLabs and the technologies; they are just tools. Instead, it is about the schools and the learners – their approach to FabLab

	activities and what happens at the schools – once the teachers have completed their Pioneer Teacher training. In a future perspective it may be relevant with further investigations regarding the extent to which the investment in the teacher training program have made an impact on the teaching practice at the local schools.
Further information can be found at: Web/Social Media/contact person, etc.	https://fablearn.org/ https://fablabatschool.dk/ Casestudy

Name of Existing practice	**NEMESIS Project: Novel Educational Model Enabling Social Innovation Skills**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Germany, France, Greece, Portugal, Spain, UK
Institution (running the activity)	
Implementation year and duration (in hours, and number of sessions)	2018-2020
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	NEMESIS stands for "Novel Educational Model Enabling Social Innovation Skills" and it is a European project bringing together education and social innovation. NEMESIS represents a new approach towards the attainment of social innovation skills by combining innovative learning models, open technologies, and participatory relations and processes. The objective is to foster entrepreneurial mindsets and creative thinking among primary and secondary students, allowing them to become the social innovators of tomorrow.
Connection to school curricula (YES/ NO)	YES

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Target and age groups (teachers or students)	Students and teachers of primary and secondary education
Location(s) (where the activity takes place)	• Classroom, formal learning space, etc. However, the NEMESIS model itself could be applied in any learning environment either on a formal, informal or non-formal level.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Teachers, students, parents of the students, the social innovation practitioners as well as local authorities and any other local stakeholder that the students in collaboration with teachers decide to involve. The selection of SIPs and local bodies that will be engaged in the process is dependent upon the content and topic of the project that students decide to work on.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Creating a social innovation in real life is a non-linear process but it starts with something, somewhere or someone inspiring another to form an idea. The co-creation labs simulate a process of Social Innovation as participants are looking for inspiration and ideas for a social project to then use in their educational setting. Students work in teams and choose a social issue they feel passionately about and gain an in-depth understanding of the issue. They collaborate with each other, involve people inside and outside their educational setting and create links within their community. Through this process, students experience a variety of cocreation approaches that enable, among others, the development of creative and innovative problem-solving skills focussed on human centred design. Hence, within NEMESIS co-creation labs combine different pedagogies and educational methods by making the required adaptations so as to best serve the learning objectives of the NEMESIS model. Collaborative learning, Project based learning, Service learning, design thinking and digital storytelling are the main approaches and tools that form the pedagogical basis of the co-creation labs.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic?	The main learning objectives are: - help teachers and non-formal education trainers to apply co-creation methodologies and foster collaborative learning towards Social Innovation. - To increase educators understanding on the opportunities of co-creation and foster interactions with Social Innovation Practitioners (SIPs) and other stakeholders (parents, educators, public authorities etc.) in the promotion of learning.

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▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	- Through the implementation of NEMESIS students are harnessed with 13 Social innovation competences and also their engagement and empowerment is being greatly positively affected from a cognitive, emotional, behavioural and agentic perspective. - the promotion of a culture of social innovation within schools and the change in teachers' mindsets and beliefs.
Development and/or reinforcement of skills and which ones	The NEMESIS model seeks to cultivate 13 social innovation skills. Throughout the implementation of the model in schools, a progress development of those skills is being recorded so as to make sure not only their development but also the level of understanding from students of what each one entails and the sort of activities that teachers need to apply so as to harness them.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	The evaluation strategy employed during the first pilot year of the project was informed by a realist approach which enabled the team to go beyond "what happened" and towards understanding "why it happened". The evaluation strategy had various iterations – at the beginning, during and at the end of the school year whereby the NEMESIS model was being applied. Students, teachers, parents, social innovation practitioners as well as any other local authority or individual participating in the co-creation labs has assessed the model in its totality- from the progress in cultivating the 13 si skills to the effects and impacts it had on themselves.
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Human resources: teachers willing to support the application of nemesis in their classrooms Guidelines already developed for teachers to look and work on.
Success criteria or obstacles identified for the practice	The model is in its second year of application and implementation in schools and has shown great progress in students' competence development . The teacher training is something that needs to be boosted and this is taken into account for next year whereby specialized moocs will be created for this cause

Further information can be found at: Web/Social Media/contact person, etc.	https://nemesis-edu.eu/ https://nemesis-edu.eu/nemesis-platform/

Name of Existing practice	**CoderDojo**
A photo or logo of the practice would be nice	CoderDojo
Country or countries that it is applied	Global: There are now more than 1,900 verified Dojos in 93 countries.
Institution (running the activity)	CoderDojo foundation
Implementation year and duration (in hours, and number of sessions)	From 2011 ongoing.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	The CoderDojo movement believes that an understanding of programming languages is increasingly important in the modern world, that it's both better and easier to learn these skills early, and that nobody should be denied the opportunity to do so. To that end, we've built a global network of free, volunteer-led, community-based programming clubs for young people. Anyone aged seven to seventeen can visit a Dojo where they can learn to code, build a website, create an app or a game, and explore technology in an informal, creative, and social environment.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Children 7 to 17

Location(s) (where the activity takes place)	• Community lab, • Museum, science centre, outreach centre
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Volunteers, programmers, venue owners.
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Problem-based learning
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	A change in the development and/or reinforcement of skills. A change in knowledge and understanding of a scientific topic.
Development and/or reinforcement of skills and which ones	Programming

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Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	Programming knowledge. Knowledge of setting up a network.
Success criteria or obstacles identified for the practice	
Further information can be found at: Web/Social Media/contact person, etc.	https://coderdojo.com/

Name of Existing practice	**GirlsGarage**
A photo or logo of the practice would be nice	

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Country or countries that it is applied	US, Berkeley CA
Institution (running the activity)	Project H Design
Implementation year and duration (in hours, and number of sessions)	Ungoing since 2013.
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Girls Garage is a nonprofit design and building program and dedicated workspace for girls and female-identifying youth ages 9-18. Since 2013, Girls Garage has been supporting girls in their quest to Fear Less and Build More! Through afterschool classes, summer intensives, and workshops, our design and building programs promote creativity, grit, and curiosity through hands-on construction, problem solving, and meaningful making. Under the guidance of our skilled all-female staff, girls develop skills in carpentry, welding, architecture, engineering, graphic design, and applied STEM concepts through full-scale building projects for real-world clients. While working toward our 10-module Fearless Builder Girl certification, our girls discover and use their creative voices to transform their communities and go forth confidently into higher education and careers
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Girls and female-identifying youth ages 9 to 18.
Location(s) (where the activity takes place)	• Community lab, FabLab
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	Students, Educators, Space holders, Clients.

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Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	Project-based learning
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic? ▫ A change in engagement /interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic?	A change in the development and/or reinforcement of skills: Applied skills. A change in Attitude: Self-efficacy.

▫ A change in the development and/or reinforcement of skills?)	
Development and/or reinforcement of skills and which ones	Applied skills: Wood working & Carpentry, Metal Working & Welding, Enterpreneurship, Engineering/Architectural Concepts.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how, who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	-
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	An advanced workshop/fablab Skilled staff with educational and building experience.
Success criteria or obstacles identified for the practice	-
Further information can be found at: Web/Social	https://girlsgarage.org/

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Media/contact person, etc.	https://girlsgarage.org/app/uploads/2019/06/GirlsGarage_ImpactStatement_June2019.pdf

Name of Existing practice	**Kids Can! Innovation camp**
A photo or logo of the practice would be nice	
Country or countries that it is applied	Manila, Philippines
Institution (running the activity)	International group of educators from Asian and European countries but started officially at the Xavier School in the Philippines.
Implementation year and duration (in hours, and number of sessions)	June 2017 Takes one day (about 6 hours) in total, but could be spread over multiple days
Brief description of the practice (in terms of its vision, the activities undertaken, the existence and role of facilitator, if present)	Kids Can! Innovation Camp provides students with the opportunity to lead their own learning as they tackle real-world problems aligned to UN SDGs through interdisciplinary project-based learning challenges. Through empathy-driven design-thinking and the use of Makerspace and ICT tools, students are empowered to create and design solutions in the form of projects and products.
Connection to school curricula (YES/ NO)	NO
Target and age groups (teachers or students)	Students of grade school and middle school

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Location(s) (where the activity takes place)	The workshop takes place in a classroom at school.
Stakeholders involved (from teachers, to parents, local community, ngos, etc.)	School, a project team at the school (including a project head, SDG mentor, Design Thinking mentor, multiple Project mentors and a logistics head).
Brief description of the main activities and pedagogical approach followed (Please select among the following that best describe the activities undertaken: problem-based learning, project (or task)-based learning, design-based learning, collaborative-learning, social purpose oriented, involving families/ communities)	• In the first 40 minutes, the SDGs are explored and explained, which basically are the core of this project. The SGDs are the goals to these projects, providing social relevance and basis for the works of the participants. • Then, students explore the design-thinking framework. This aims to make the students familiar with the process since this is a crucial framework for the projects. • Then, students fill in the empathy map. The empathy map is a tool that helps learners to know and feel for another person or simply, to be in the shoes of the person of interest. It helps the learners to empathize with the people for which they are designing a solution. The map leads the learner to examine what the person thinks or feel, sees, hears, says, or does. Lead the learners to use vivid descriptors. • Then, the students enter the imagine & plan phase. Students lay their plan on how to solve or provide a solution to the problem. They identify as many solutions as they can. In the end, they need to choose the “best” solution according to feasibility, effectivity, and efficiency. • Then, the students build their product or project. • Then, the students present their product or project to a wider audience. It can be through a project presentation, public demo or display, or private presentations to key persons connected to their cause.
Learning objectives identified (What does this practice seek to achieve? ▫ A change in knowledge and understanding of a scientific topic?	At the heart of “Kids Can! Project” is the goal of involving, engaging, and providing children the opportunity to become critical thinkers, creative problem solvers, and active agents of change. • As critical thinkers, they investigate and ask questions about the problems and challenges that the world is experiencing.

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▫ A change in engagement/interest in a scientific topic? ▫ A change in attitude towards a scientific topic? ▫ A change in behaviour related to a scientific topic? ▫ A change in the development and/or reinforcement of skills?)	• As creative problem-solvers, they used their talents, skills, and immediate resources to plan, create, test, and improve their solutions to the problems. • As active agents of change, they use their ideas and products to influence the people around them to take part in making the world a better place.
Development and/or reinforcement of skills and which ones	• The Kids Can! Innovation Camp seeks to provide grade school-middle school students the opportunity to become critical thinkers, creative problem-solvers, and active agents of change. In order to do this, Kids Can! project incorporates the United Nations Global Goals, also known as the Sustainability Development Goals of 2030, as a guiding tool for the children. • The project framework brings design-thinking to the appropriate level of the students who participate. • The project is grounded in passion-based learning. Students are given the opportunity to create products that they are passionate about. Students use their passions, talents, and skills (individual and collaborative) as they participate in creating solutions for the problems they are working on. • The project aims to help kids come up with different and genuine solutions. The nature of solutions that the students create depends on the nature of the problem they have identified. Hence, possible solutions may include but not limited to: making or inventing, information and advocacy campaigns, call to action through service, and philanthropy.
Assessment/ Reflection of the learning objectives (Are they assessing the learning objectives and how,	Nothing written about assessment or reflection.

who is assessing those? Children themselves of the facilitators? How frequent are they assessing those? Once or also along the duration of the programme?)	
Specific resources required (certain knowledge, human resources or material resources like templates to structure the process, materials for making, machinery for making, etc.)	A project team (as described before), significant time to prepare, tools to build/create the product/project.
Success criteria or obstacles identified for the practice	The project is selected as one of ten most inspiring K-12 innovations in sustainability education across the world by HundrED. (https://hundred.org/en/innovations/kids-can-innovation-camp).
Further information can be found at: Web/Social Media/contact person, etc.	https://kidscanproject.weebly.com/