Master thesis on Cognitive Systems and Interactive Media

Universitat Pompeu Fabra

A study on the development of maker activities with primary education teachers and students: from self-concept change to gender factors

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Table of Contents

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Abstract

Schools have to prepare young people for the future workplace, and there are two factors that have to be highly considered to do so: the high demand for a qualified workforce in technology and research, and the importance of knowledge and skills as the engine of our economy. Educators have to develop the 21^{st} century digital skills and maker activities seem to be a good way to do so. In this line, there are being created many projects to help the scholar community to follow the maker methodology, such as Makers a les Aules, a project developed in 10 public schools from Barcelona.

The aim of this thesis was to conduct an exploratory research about the development of maker activities with primary education teachers and students. In relation to teachers, it wanted to be analyzed which reasons drove them to develop maker activities, how does their self-concept change after following a maker methodology and what do they still need to be improved to make it easier to include these activities in the classroom. On the other hand, in relation to students, it wanted to be analyzed their prior knowledge regarding maker activities, how does their self-concept change after participating in the project and if there were any differences regarding to gender. There were posed some general assumptions based on previous literature regarding these issues. There were used different research instruments to collect mainly qualitative data such as pre-questionnaires and post-questionnaires, a case study observations and interviews. The data was analyzed through qualitative analysis and statistical methods.

Some of the assumptions were accomplished. Few teachers and nearly all students had prior experience using maker tools. There were gender differences since boys had more prior experience than girls using maker tools in specific contexts, but all of them report the same level of enjoyment. Teachers participating in the project were willing to learn how to introduce this methodology in their classroom to innovate in their lessons. They increased their perceived knowledge and ability to design and develop maker activities in the classroom. Students increased their interest and self-perceived efficacy in technology, and their level of autonomy doing maker activities. Some limitations that teachers could face for developing maker activities are the lack of knowledge, access to the material and time. Some actions should be carried out to overcome these limitations.

Keywords: 21st century digital skills, STEAM, design thinking, computational thinking, maker activities, primary education students, primary education teachers, maker self-concept, gender differences.

1. Introduction

1.1. The future for primary education students

Nowadays, our economy is driven by knowledge rather than manufacturing, employers are already valuing different skills such as creativity, communication, presentation skills and team-building. Schools are at the front line of this change and need to think about how they can prepare young people for future workplace[1]. In the knowledge society, the production of goods and services has been globalized and thousands of jobs, particularly in manufacturing, have been eliminated by automation or relocation to industrialized countries[2]. In this society, there are being rapid and far reaching technological changes, accelerated globalization, a shift towards considering knowledge as the central factor of production, more fluid and less hierarchical organizational forms, and longer life expectancy allowing different generations to share the scene[3]. In the last few years, competition has increased, the pace of life has accelerated, professions are changing, and we are facing a new kind of uncertainty. At the same time the world has become more connected and international[3].

Since we are entering a new stage in the history of education we have to educate children with different needs, but sometimes it is difficult to know how to face this change of scale[4]. The way that students are educated should be aligned to the new technologies, working environments, organizational structures and different forms of internal and external cooperation that are being stablished in the new society and in the Industry 4.0[3]. In this direction, as well as we have always been using tools to enhance our possibilities, we can use the computer as a tool for the brain, which gives an advantage for the process of globalization and education[5].

1.2. 21st century digital skills

For many years, digital technology has been completely normalized by the current students' generation and it is now integrated into their daily lives[1]. This is the reason why we need to address the abilities, knowledge and attitudes that evolve from the use of digital technology. To participate in the global digital network we need to develop a network of complex skills[4].

There are being many actions oriented to introduce the development of these skills in schools by different organizations in this country such as the document "Marco Común de Competencia Digital Docente" (Common Framework of Digital Teaching Competence) by the Ministry of Education, Culture and Sports from the Spanish Government[6] or the document "Competències Bàsiques de l'Àmbit Digital" (Basic Competencies in the Digital Field) by the Teaching Department from the Generalitat of Catalunya[7].

The document by Gobierno de España is a reference framework with the digital competencies that teachers need to have for conducting successfully their teaching practice. It structures different skills in five different areas, and it establishes six levels of expertise. The areas that it considers are:

1. the information and informational literacy area,
2. the communication and collaboration area,
3. the digital content creation area,
4. the security area and
5. the problem-solving area.

Firstly, the information and informational literacy area makes reference to the ability for searching, evaluating and storing data collected from digital resources; secondly, the communication and collaboration area refers to the interaction, sharing, citizenship participation, collaboration with others, behave properly and administer digital identity through digital applications; thirdly, the digital content creation area is related to developing new digital content or using the existing one modifying it, taking into account the royalties, and being able to program informatic programs or modify existing ones and use it for educational purposes; fourthly, the security area for protecting the devices used, protecting personal data and digital identity, avoiding health risks, and protecting the environment; and lastly, the problem-solving area includes to be able to solve technical problems, identify needs for using resources and how to provide solutions, innovate and use technology creatively using it as a source of expression, and identify which digital skills should be improved in oneself and the others[6].

The document by Generalitat of Catalonia specifies the skills that students need to have to be able to interact successfully with today's society. There are ten competencies classified in four dimensions. The dimensions are:

1. tools and applications,
2. information management and organization of the learning and working environments,
3. interpersonal communication and collaboration, and
4. digital identity, civic-mindedness and habits.

In the dimension for tools and applications, the competencies that should be developed are selecting, using and programming digital devices depending on the tasks that are being carried out, using the basic functions of text editors, number editors and multimedia presentations, and using programs and applications for creating and editing drawings, sounds and videos. In the second dimension, information management and organization of the learning and working environments, the competencies that should be developed are the ability of searching, comparing and selecting digital information considering different sources, constructing personal knowledge through the use of digital devices, and organizing the work and learning in digital environments. In the third dimension, interpersonal communication and collaboration, the student has to develop the competence for communicating virtually and using digital publications, and for working in teamwork taking advantage of virtual collaborative environments. Lastly, in the dimension for digital identity, civic-mindedness and habits, the competences that have to be developed are health usages of technology and responsible, critical and prudent way of acting when using digital technologies by considering ethical, legal, security, sustainability and digital identity issues[7].

In Catalonia, the education centers are legally obligated to review and update the scholar curriculum for the correct use of digital technologies in the education and learning process. This has to be done in the context of "pla TAC", standing for Technologies for Learning and Knowledge (Tecnologies per l'Aprenentatge i el Coneixement, in Catalan) which is the tool that facilitates the organizational planification for the introduction of these technologies[8].

However, from a systematic literature review, it has been concluded that the 21st century skills and the digital skills are concepts that emphasize a broad spectrum of skills.

Furthermore, knowledge and attitude are also viewed as essential to develop in the knowledge society[9]. This is why we should refer to the competences that need to be developed as the 21st century digital skills instead of just digital skills or 21st century skills. There have been defined seven core dimensions of the 21st century digital skills, which are:

1. technical aspects,
2. information management,
3. communication,
4. collaboration,
5. creativity,
6. critical thinking, and
7. problem solving.

Firstly, the technical aspects such as understanding and using information and communication technologies (ICT); secondly, the information management in relation to the fact of defining the research statement using ICT, accessing the information from online sources, evaluating the usefulness and sufficiency of information using ICT and managing the organization of the information using ICT; thirdly, communication based on the skills to use ICT to transmit information to others; fourthly, collaboration thanks to the use of ICT to develop a social network and work in team; fifthly, creativity, using ICT to generate new or unknown ideas or to create new products or services; sixthly, critical thinking developed through the correct use of ICT to make informed judgements and choices clarifying questions, judging the suitability of a source, invoking arguments, linking ideas and suggesting new ideas for discussion; and seventhly, problem solving using ICT to cognitively process and understand a problem and find a solution acquiring implicit and explicit knowledge and applying it[9].

Other five 21st century dimensions of digital skills that must be connected to the core ones mentioned, are the contextual ones. These ones allow to take advantage of the core ones and are:

1. ethical awareness,
2. cultural awareness,
3. flexibility,
4. self-direction, and

5. lifelong learning.

Firstly, ethical awareness means to behave in a socially responsible way making a responsible use of ICT and understanding its social, economic and cultural impact; secondly, cultural awareness means to show cultural understanding and respect towards online communication with people from different cultures; thirdly, flexibility includes the skills to adapt one's thinking, attitude or behavior to changing ICT environments; fourthly, self-direction is the ability to use ICT to set goals for oneself, take control of them, take steps towards the goals and monitor the progress; and fifthly, lifelong learning for constantly explore new opportunities when using ICT to create useful knowledge individually[9].

1.3. The importance of STEAM

The demand for a qualified workforce in technology and research sectors is and will remain at a high level. Greater efforts must now be made to highlight these areas as a priority in education and increase engagement at all levels[10], that could be done through the introduction of STEAM.

The word STEAM refers to the fields of science, technology, engineering, art and mathematics. Georgette Yakman, who is considered to be the founding researcher and creator of the STEAM education[11], exposes that we can't consider science and technology as something separated since we can't understand science without technology, which is developed through engineering that needs an understanding of arts and mathematics[12]. Furthermore, art is also considered as the field that creates excitement for developing the other fields[13].

In the scholar level, these fields should be taught in thematic units where teachers from different disciplines plan their lessons around the accorded topic in a way that students can make connections within all the different fields[12]. It has been proved that in projects where these fields are applied, students can enjoy learning at the same time that develop the skills necessary for scientific and industrial goals[13].

1.4. Design Thinking

Since the goal of education is to prepare students to succeed both within and outside school and not only on standardized exams, design thinking can provide the opportunity to develop the set of skills that can help them to achieve this goal[14]. Introducing students to design thinking would help them to be prepared to deal with difficult situations and to solve complex problems in school, in their careers and in life in general moving beyond the limit of increasing students' proficiency in traditional subjects[14].

Design thinking derives from the designers' way of thinking, from their mindset and approach to work, but it is a method that anyone can use[3]. It combines empathy for the context of a problem, creativity in generating ideas, insights and solutions, and rationality to analyze and match solutions to the context. It also promotes a collaborative approach where everyone contributes to its knowledge and experience[3]. In an education context, design thinking facilitates learning experiences based on transdisciplinary approaches, supports it by a project-based learning and allows to put into practice knowledge from different fields of study to deliver a solution to a specific problem. Design Thinking promotes the ability to use a process to understand people and situations, define problems and come up with innovative solutions; it also demands to work on hands-on projects, promoting empathy, ideation and active problem solving[15].

Due to Paulo Freire, one of the most influencing educators of the 20th century, to enhance students' learning, the projects that they do should be connected with meaningful problems so that designing solutions to those problems would become educational and empowering[16]. In relation to this, enhancing students' design thinking skills could be achieved through the incorporation of authentic and intriguing tasks into the classroom and providing many opportunities to apply design processes[14].

There are many models that define the different phases of design thinking such as the d.Schools model developed by the Stanford University, the different models developed by IDEO such as the "3 I's", the "HCD" or the "DT for Educator" model, the "Evolution 6^{2}" model developed by Katja Tschimmel, among others. In the project Change Makers, an Erasmus+ project, it has been proposed an adaptation of the d.School model that provides a set of the main competences developed through design thinking in the context of the schools educational curriculums[15].

The model generated by the Stanford University consists of five phases[15,17]:

1. The first one is Empathy, and in this phase, it is important to understand the problem that is being faced; the competencies that are developed in this phase are emotional intelligence, capacity to observe, learning from the real world and questioning.
2. The second one is the Define phase where the problem is defined from what has been understood in the first phase; the competencies developed in the Define phase are those related to reflecting on experiences, problem-based learning and critical thinking.
3. The third phase is Ideate and it is at this point where there a large number of ideas are explored to solve the problem that has been defined; the competencies developed are visioning, storytelling or narrative capacity to picture scenario, agency and capacity to take initiative.
4. The fourth phase is Prototype, that helps to get the ideas out of the head and put them into the world; the competencies that are developed are problem solving, capacity to concretize, capacity to adapt, implement, create or build capacity, and experimentation embracement.
5. Lastly, the fifth phase is Test, and it is in this moment when you gather feedback from the prototype created and refine solutions; the competencies that should be developed in this phase are the capacity to evaluate, to analyze, to validate, to share and also to learn from mistakes. This method is iterative, so it is allowed to go back to other stages when needed.

1.5. Computational thinking

Another concept that should be taken into account when talking about the development of the 21st century digital skills on students is computational thinking. Computational thinking is influencing every field of study and work and is becoming a fundamental skill for the 21st century, which raises the educational challenge of integrating computing principles in teaching practices[18,19].

Computational thinking comes from the field of computer science but it is a fundamental skill for everyone, not just for computer scientists[20]. It is a way of approaching complex problems which permeate every-day mental activities[21]. Jeannette Wing, a strong promoter of computational thinking at MIT, defines it as an approach to solving problems, designing systems and understanding human behavior by following a procedure based on computer science[20].

In relation to the STEAM fields, it could also be seen as a bridge between science and engineering, since it takes place in transitioning from the study of physical phenomena to the application of scientific observation[21].

It has been considered that computational thinking has five dimensions: abstraction, generalization, algorithm, modularity and decomposition. These dimensions are related to different skills that can emerge when it is applied in education.

1. The first dimension, Abstraction, is the process of creating something simple from something complicated, Wing poses that it is the essence of computational thinking[19]; the skills that are developed in this phase are the ability to separate the important from the redundant information and analyze and specify common behaviors or programming structures.
2. The second dimension is Generalization, it is transferring a problem-solving process to a wide variety of problems; with Generalization students should be able to expand an existing solution in a given problem to cover more possibilities or cases.
3. The third dimension, Algorithm, is a practice of writing step-by-step specific and explicit instructions for carrying out a process; the skills developed in this stage are the ability to state the algorithm steps, identify different effective algorithms for a given problem and find the most efficient algorithm.
4. The fourth dimension is Modularity, the development of autonomous processes that include a set of often used commands necessary to perform a function that can be applied in the same or different problems; in this case, when coding, students should be able to develop autonomous code sections.
5. The last dimension, Decomposition, is the process of breaking down problems into smaller parts that may be more easily solved when attacking or designing a large complex task; students should be able to break a problem into smaller or simpler parts that are easier to manage[19,22,23].

Some teachers use to struggle when trying to understand what computational thinking is and how it should be applied in their classrooms, but it has been proved that introducing it into education courses, helps them to understand what it is and increases the probability for them to introduce it in their teaching practices. More specifically, when giving computational thinking lectures to teachers, they see computational thinking as a way of solving problems because it involves using specific skills and strategies to solve problems in the most logical and effective way, as well as they see that they can introduce this method in their class to teach students how to approach questions and concepts[24]. Furthermore, students themselves, after understanding what computational thinking is, realize that it can be integrated into their lessons by promoting problem solving and critical thinking skills[18].

Nevertheless, in the field of computing there are not only computational concepts to teach, but there is also a tool, the computing machine, that provides challenges and opportunities useful for teaching[19]. This is the reason why, despite computational thinking is more than programming, programming is an important tool to help develop computational thinking[25]. It has been proved that technology and computer game courses for middle school students are a promising strategy to introduce computational thinking[26].

1.6. The influence of gender

In previous studies, there have been seen differences on technology and maker activities when comparing students by their gender, for instance, boys have shown higher levels of confidence in academic areas related to mathematics, science, and technology in comparison to girls, despite of not having found differences related to achievement in these areas[27,28]. In some studies, it has been seen that although girls enter the course with less confidence than boys, girls' confidence increases more than boys' by the end of the course[29].

Furthermore, in previous studies males have reported to have more extracurricular experiences with a variety of tools such as batteries, electric toys, fuses, microscopes, and pulleys; on the other hand, females reported more experiences with bread-making, knitting, sewing, and planting seeds[30].

Nevertheless, it has been seen that participating in maker activities can change stereotypic gender beliefs increasing positive attitudes about engineering and science[31,32].

1.7. The maker methodology in education

It has been explained the importance of preparing children for the future where they will develop and the importance of fostering the 21st century digital skills among them through the introduction of the STEAM fields, Design Thinking and Computational Thinking. One way of putting all these concepts together is through the implementation of the maker methodology, a concept that comes from the maker movement, which refers to people who enjoy producing creative artifacts in their daily lives[33].

Maker activities could support learning processes that involve the 21st century skills acquisition and not focus only on a specific subject[34,35].

There had been defined two main characteristics of making in relation to its power supporting elementary education[35]:

1. The first one relates to what Seymour Papert, an important mathematician and educator from the 20th century who received important influences from Jean Piaget, a biologist and psychologist that developed remarkable theories about infancy and constructivism, claimed exposing that the construction of knowledge happens better when students build, make and publicly share objects; this is what "making" and digital fabrication mean for education[16]. There is a necessity of making to integrate prior knowledge and skills[35].
2. The second characteristic of making is the fact of allowing utilitarian activities, what makes it different than mere instruction. Vigotsky, a psychologist who proceeded Seymour Papert with its concept of "zone of proximal development", exposes that a student can receive certain concepts in the course of instruction but these concepts will only be learned when using it in daily live[35].

Since maker activities involve the use of some type of digital material, users have to be familiarized with technology and broaden the interest in computer science in general[34]. It is considered that education should provide all children with the opportunity to design and develop digital technologies and not only use them[36]. Papert, already mentioned, advocates that technology in school is an emancipatory tool that puts the most powerful construction materials in the hands of children, it doesn't have the purpose to optimize traditional education[16]. It is expected that maker sessions can engage students in the design and fabrication process, in thinking and problem solving, as well as in programming[34].

Most of the research has proved the efficacy of introducing maker activities in curricular areas related to science, technology, engineering and mathematics, which challenges us as researchers, teachers and/or educators to see in which other subject areas it could benefit[34]. When introducing a makerspace, an area where students go to explore, build, create and tinker, students get engaged in intellectual activities and practices that would not be possible anywhere else, letting them experience new ways of working and increasing the levels of team collaboration[16]. Using robots to teach problem-solving, critical thinking and basic programming concepts, has shown to improve students' knowledge about robotics and programming, increasing students interest in STEM[37]. It has been also shown that doing maker activities increases the self-efficacy of the participants, making them gain confidence, enjoyment and interest in programming and technology[34]. It has been also seen that introducing making in the classroom can influence students' self-perceptions by creating a Maker mindset determined by three factors[35]:

- Motivation: initiative to engage in making activities
- Interest: degree of engagement in making activities
- Self-efficacy: perceived ability to perform in specific making tasks

Moreover, it has been demonstrated that it can be effectively and economically implemented in the elementary school curriculum[38].

In the teachers' community, it is known that this movement is leading the path of education, but some of them struggle to implement it in their practice for different reasons such as problems with access, time, beliefs, professional development and institutional vision[39]. This is why many projects are being created to help teachers to introduce this meaningful methodology in their teaching practice.

1.8. Research questions and assumptions

Having seen the importance of introducing the maker methodology in the school, the main objective of this research is to do an exploratory research evaluating the effect of doing maker activities in the classroom on the two groups of participants: primary education teachers and primary education students. There are posed some general assumptions based on previous literature regarding different research questions.

1.8.1. Teachers' research questions

In relation to teachers, there are defined three research questions with their respective assumptions.

The first research question is: **what does it drive primary education teachers in formal educational settings (primary education classrooms) to develop maker activities?** This question aims to identify if the reasons why teachers see as important to introduce maker activities at school, are related to the ones that have been previously postulated or not. It is assumed that they will give similar reasons to the ones mentioned, such as the development of the 21st century digital skills which include technical aspects, information management, communication, collaboration, creativity, critical thinking, and problem solving[9,34,35]; as well as competencies that are developed when doing maker activities such as learning of the tool, integration with other subjects, teamwork, increment of the interest for the STEAM fields and also an improvement of the student's self-concept and efficacy[34,35,37].

The second research question is: **how does it change the self-concept of primary education teachers, to participate in maker activities?** With this question, it wants to be proved the effect that it has on teachers' self-concept the fact of participating in a program that supports them in the integration of the maker methodology in their classroom. Based on the studies that have been presented, it is assumed that teachers will improve their self-perception feeling more confident to implement and create maker activities for their lessons[18,24].

The third and last research question is: **what are the implications that need to be taken into account to help primary education teachers to design and implement maker activities in primary education settings?** With this question there want to be addressed the different fears and doubts that teachers can have when using the maker methodology, with the purpose of collecting this information to improve future interventions. It is assumed that the main problems that they will perceive will be related to time management, knowledge, access, connectivity and institutional vision, as seen in previous research[39].

1.8.2. Students' research questions

In relation to students, there are three research questions that aim to be answered, also with their respective assumptions.

The first research question in relation to students is: **do primary education students know what maker activities, or maker tools, are?** Since the maker movement is having a growing interest in education, with this question it wants to be explored if students are also aware of this concept. It is assumed that, thanks to the significant number of projects that are being developed in schools with the use of different tools for programming, they will be aware of some of the tools that can be used in the maker methodology, concretely, they will be familiar with the programming language Scratch, the most frequently used maker tool[34].

The second research question is: **how does it change primary education students' self-concept, to participate in maker activities?** Similar to the case of teachers, with this question it wants to be proved the effect that it has to introduce maker activities in the classroom. Also, in relation to the literature that has been presented, it is assumed that students will be more motivated and engaged to develop maker activities after having participated in the project[38,40] as well as they will also improve their self-perception in relation to their capacity, confidence and autonomy for developing such activities[34].

The third and last research question is: **Are there any differences depending on the primary education students' gender?** According to previous literature, it is assumed that boys will have more prior knowledge than girls[30], but after having participated in the project, girls' self-confidence will suffer a bigger increment in comparison to boys'[29].

2. Methodology

2.1. Research setting: Makers a les Aules

This study is developed in the context of the project "Makers a les Aules". This project has been organized by the University Pompeu Fabra in collaboration with Barcelona Activa and the Maria de Maeztu DTIC-UPF program. Its goal is to capacitate primary education teachers in the creation of a maker project based on STEAM and its implementation it in the classroom, in a way that both, teachers and students, learn at the same time.

It is a 10 hours program organized in 6 different sessions. The first session is a two-hour meeting between the teacher of the classroom who is participating in the project and an expert instructor who will guide the teacher through the different phases of the creation and implementation of a maker activity. In this meeting, it is defined the topic on which the project will be developed, the maker project that will be done and the tools that will be needed, it is followed a design thinking process for the design of this activity. After this two-hour meeting, there are four sessions of one hour and a half that take place in the real context of a classroom with all the students involved in the development of the project that was defined, guided by the instructor and the teacher. Lastly, there is a two-hour trip to a makerspace.

Depending on the tools that will be used for the maker project, the schools participating are divided into three groups. Concretely, the tools that are used are Scratch, Makey Makey and Tinkercad. Scratch is a programming language that was created by the MIT that allows to program through the combination of visual programming blocks to create an animation or a game. Makey Makey is an electronic tool that allows to connect everyday objects to computers to develop specific programs using Scratch. Tinkercad is a software application developed by Autodesk that allows to create 3D designs and print them with a 3D printer. Concretely, 3 schools used Scratch, 3 schools used Makey Makey and 4 schools used Tinkercad.

Different projects have been developed in each school regarding the tool that they were using and the topic that they were learning at that moment of the academic year. There have been developed 10 different projects, one for each participating school, which are related to different academic areas.

- School 1 worked on interactive maps connected with Makey Makey and programmed with Scratch, a project related to social sciences and geography.
- School 2 worked on a geometry themed battleship game using Makey Makey and Scratch, a project related to the area of mathematics.
- School 3 created an animation about the water cycle using Scratch, a project related to the natural sciences area.
- School 4 created a videogame with Scratch, a project related to the digital field.
- School 5 worked on inventions to improve the environment using Tinkercad and 3D printing them, a project related to natural sciences.
- School 6 created a noise meter using Scratch, a project included in the field of mathematics.
- School 7 worked on significant objects of Ancient Age stories using Tinkercad, a project in the field of social sciences.
- School 8 designed genderless toys using Tinkercad and a 3D printer, a project related to values education.
- School 9 created interactive posters themed on the Prehistory with Makey Makey and Scratch, a project in the field of social sciences.
- School 10 designed futuristic buildings using Tinkercad and a 3D printer, a project in the field of social sciences.

One group of students was participating in each school, except in school 10 where there were 2 groups of students (called group 10 and group 11).

2.2. Measurement tools

There were used questionnaires, observations and interviews. These tools were used in different moments of the study and with different participants (see Figure 1). The questionnaires and the observation grid are attached in the appendices.

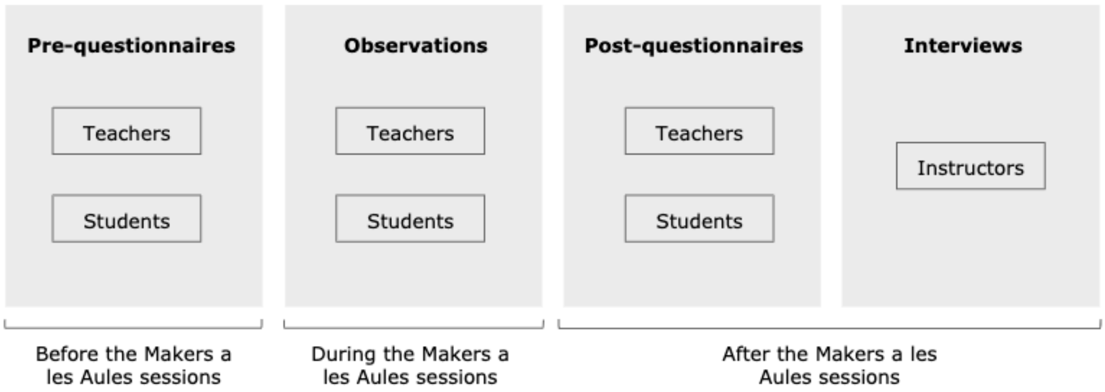

Figure 1. Schema of the measurement tools used, participants and moment of distribution

2.2.1. Questionnaires

Different questionnaires were elaborated for the two participant groups, with different questions and different formats depending on the data that had to be collected and the participants' level of literacy.

The data collected from the questionnaires consisted of written responses about opinions or practices related to the use of maker tools. This data was necessary to investigate the previous experience of participants with maker activities and educational technologies, motivations to participate, and some data about the possible effect of maker activities on children. It was also looked for evaluating the effectiveness of the study.

The methodology that would be applied to analyze this data would be descriptive statistics, chi-square independence test, dependent and independent t-test and content analysis.

2.2.1.1. Teachers' questionnaires

For administering the questionnaires to teachers, it was used Google Forms. There were developed a pre-questionnaire and a post-questionnaire, being the first one shared with teachers one week before the initial meeting with the instructor, and the last one administered one day after the trip done on the last day.

In the pre-questionnaire there was first asked some personal data such as gender, age and the school where they were teaching. Then, there was asked for some previous experience to know if they had ever used any tools before the project, to what frequency, in which subjects and they were also asked to assess their experience on a Likert scale. Continuedly, there were asked to share their project expectations explaining their motivation to participate, their professional hopes, meaning their willingness to apply what they learn to their lessons, how useful did they thought that this would be in their teaching practice, and the short-term and long-term benefits that they thought that this would have on their students. Lastly, they were asked for a personal assessment about themselves based on different statements with the ones they had to agree or disagree in a based on a Likert scale going from 0 to 4, they were also asked about the limitations that they thought that could face, and some actions that would be needed to overcome them. Going into greater detail, the statements that were mentioned in this last part were related to their self-concept in relation to being able to use maker tools, their perceived capability to design and implement maker activities, their perceived knowledge and training opportunities, etc.

On the other hand, in the post-questionnaire, they were first asked if they had had any extra experience on maker methodology while the project was being conducted, just as a control variable. Then they were asked for their assessment of the Makers a les Aules project in relation to the workshops' usefulness, the positive and negative aspects that they saw, if they would recommend it to other teachers and, again, the short-term and long-term benefits that they thought that this would have on their students. Lastly, they were asked again for the same personal assessment that they made in the pre-questionnaire, with the same questions and statements.

2.2.1.2. Students’ questionnaires

For the questionnaire’s administration to students, there were used paper-based forms so that it was more familiar for them to answer.

Since students were supposed to understand what “maker activities” were, it was needed to conduct a pilot to prove the best way to explain it to them before they were answering the questionnaire. It was first tried with a short description in the same sheet of paper of the questionnaire, but it wasn’t enough for them, teachers would have to be explaining it to them. As if it was done this way it could have biased the children’s understanding, it was decided to prepare a short presentation with slides that would guide students to the point of clearly understanding what “maker” means. This presentation was done at every first lesson before the pre-questionnaire was administered.

In the pre-questionnaire, students were asked for some personal data such as their gender, age and school. Then, they were also asked for their previous experience with maker activities by asking them if they had ever heard the word “maker”, if they had ever used any of the tools listed and, in case they did, where had they used them, it is in which context such as at school or at home. Lastly, similar to the case of teachers, students were also asked for some personal statements which had to be answered on a Likert scale from 0 to 4 depending on their level of agreement. The statements were related to their feeling of being good at technology, at doing maker activities, their interest in maker activities, etc.

In the post-questionnaire, firstly, they were asked for a project assessment where they had to name what they had liked the most and the least, if they would like to do more maker activities, and their feeling of “being a maker”. Lastly, they were asked again to rate the same statements than in the pre-questionnaire.

2.2.2. Observations

Observations were carried out to understand what worked and what needed to be improved in the experiments and technological tools. Also, to see if there were interesting observable behaviors from participants. The data had to be analyzed through a qualitative study with its respective content analysis.

A grid was designed to keep track of what was happening in the classroom in the different lessons. This grid specified some aspects to be annotated in relation to students and teachers.

In relation to teachers, there were observed aspects related to their interest and motivation, their participation, their confidence and rapprochement to the tool, some learning and their functions and roles.

In relation to students, there were points related to their attention, their interest and motivation, their participation, difficulties that they could face, frustration behaviors, impatience, learning and gender differences.

2.2.3. Interviews

There was designed a semi-structured interview with open-questions which was done with the three instructors to get external qualitative data about the behavior of teachers and students, and to evaluate the effectiveness of the study with more concrete opinions. The data was going to be analyzed through content analysis.

The questions were mainly related to participants' participation, changes in their behavior along the sessions, limitations faced and possible improvements.

2.3. Detail of the data collected

There are presented two tables with the detail of the data collected from the measurement tools mentioned, the use of the data and the methodology used to analyze it.

Table 1. Teacher data table

	Data Collection	Type of Data	Use of Data	Methodology
Questionnaires	Online forms, given prior and after the study.	Written responses about opinions or practices related to the use of given mockups.	To investigate the previous experience of teachers with maker activities and educational technologies, motivations to participate, thoughts about the effect of maker activities on children. To evaluate the effectiveness of the study.	Case study (descriptive statistics, chi-square test, t-test and content analysis)
Observations	Researchers observations during a case study.	Notes and photos to document participants engagement, comfort-level, and understanding.	To understand what worked and what needs to be improved in the experiments and technological tools.	Instrumental case study: Qualitative (case study)
Interviews	Semi-structured interviews to the instructors after the project.	Spoken responses about beliefs and approaches related to teachers' participation in Makers a les Aules.	To evaluate the effectiveness of the study with more concrete opinions.	Content analysis

Table 2. Student data table

	Data Collection	Type of Data	Use of Data	Methodology
Questionnaires	Paper-based forms, given prior and after the study.	Written responses about opinions or practices related to the use of given mockups.	To investigate the previous experience of students with maker activities and educational technologies. To evaluate the effectiveness of the study.	Case study (descriptive statistics, chi-square test, t-test and content analysis)
Observations	Researchers observations during a case study.	Notes and photos to document participants engagement, comfort-level, and understanding.	To understand what worked and what needs to be improved in the experiments and technological tools.	Instrumental case study: Qualitative (case study)
Interviews	Semi-structured interviews to the instructors after the project.	Spoken responses about beliefs and approaches related to students' participation in Makers a les Aules.	To evaluate the effectiveness of the study with more concrete opinions.	Content analysis

3. Results

The participants were requested to firm a consent form to participate in the study. They were informed that they the option to opt-out to answer at any moment. Students' names and teachers' emails were required to match pre and post questionnaires and activities. However, their data was de-identified prior to analysis for research purposes.

3.1. Questionnaires statistical analysis

The statistical analysis that were performed to analyze the data collected with the questionnaires and evaluate the effects of participating in the program, were mainly descriptive analysis, categorical analysis, dependent t-test, independent t-test and khi-square independence test. Content analysis (inductive thematic analysis) was applied to categorize the qualitative data.

3.1.1. Teachers' questionnaires results

A total of 17 teachers from public schools in Barcelona participated in the project Makers a les Aules. Only 16 responded the pre-questionnaire and 15 the post-questionnaire. In average there were 2 teachers participating in each school. Most of them were females (68.75%, N = 11), there was one person who decided not to say its gender (6.25%, N = 1) and the rest of participants were males (25.00%, N = 4) (see Figure 2). Their mean age was 40.19 years (*SD* = 6.058) (see Figure 3).

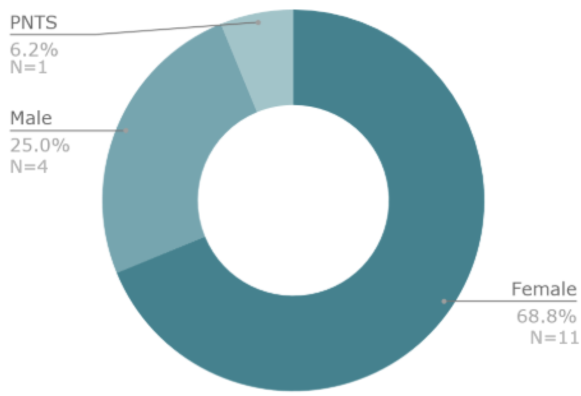

Figure 2. Gender distribution of teachers

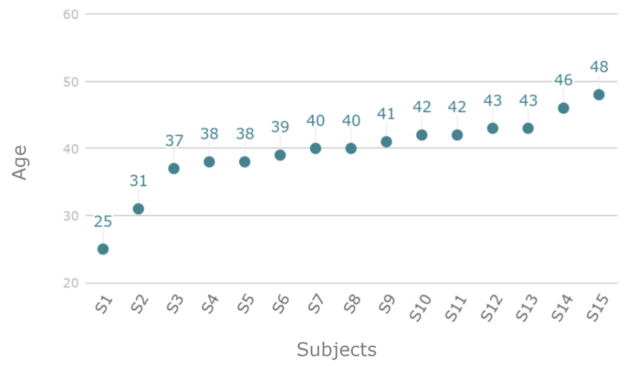

Figure 3. Age distribution of teachers

A. Teachers' previous experience

From the 16 teacher that answered the pre-questionnaire, some of them had previous experience with maker activities (31.25%, N = 5) (see Figure 4), all of them with Scratch (100.00%, N = 5) (see Table 3). All of them valuate the experience of doing maker activities as good (20.00%, N = 1) or very good (80.00%, N = 4).

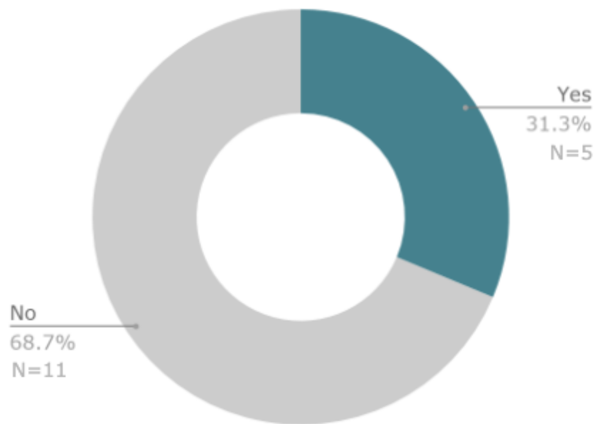

Figure 4. Prior experience distribution of teachers

Most of them had used these tools once a week (40.00%, N = 2) or once a trimester (40.00%, N = 2), being only one person that had used them once a day (20%, N = 1); and they were mainly introducing them in the subject of Mathematics (60.00%, N = 3) or programming in case they had this subject (40.00%, N = 2) (see Table 4).

Table 3. Tools used by the teachers who had previous experience

Tool	Participants (%) (N)
Scratch	100.00 (5)
Beebot	80.00 (4)
WeDo	80.00 (4)
Makey Makey	60.00 (3)
Raspberry Pi	20.00 (1)
Arduino	20.00 (1)
LEGO Mindstorms	20.00 (1)

Table 4. Subject where they had used maker tools

Subject	Participants (%) (N)
Mathematics	60.00 (3)
Programming	40.00 (2)
Project	20.00 (1)
Natural Sciences	20.00 (1)
Literature	20.00 (1)
Subject Arts	20.00 (1)

B. Teachers' motivations to participate

The first research question was: **what does it drive teachers to develop maker activities?** Regarding what motivates them for participating in the project, it was conducted an inductive thematic analysis of the 16 participants' answers and from there were generated 9 categories (see Table 5).

Table 5. Categories of teachers' motivations to participate in the project

Category	Description	Example
Innovation	To learn new methodologies that help them to innovate their teaching practices	T07: *To be able to do more innovative and motivating practices for students*
Equity	To promote equity within their students	T14: *Pedagogical innovation and equity (we are a center of maximum complexity with few resources)*
Integration	To integrate this methodology in other subjects and fields of study	T04: To b*e able to apply this methodology in other areas*
Department	To work with a content that has been set compulsory from the Department of Education	T03: *It is a content that is determined by the Department and it is necessary to work this content with the students*
School tools	To use tools that they already have at the school	T09: *We have a printer in the school, and we will use it*
Students learning	To improve students learning on technology	T01: *Student learning about new technologies*.
Students motivation	To motivate their students in class	T07: *Be able to do more innovative and motivating practices for students*
Teachers motivation	To motivate other teachers to introduce this methodology	T15: *Integrate programming and robotics in any other area and encourage teachers to incorporate these tools as part of their teaching practices.*
Other	Other uncategorizable items	T09: *Continue working at school*

From these categories, it can be seen that the half of the teachers are motivated because they want to innovate (50.00%, N = 8) and some of them want to integrate this methodology to their teaching practice (18.75%, N = 3) (see Table 6).

Table 6. Percentage of teachers' motivations to participate in the project

Motivation	Participants (%) (N)
Innovation	50.00 (8)
Integration	18.75 (3)
Students motivation	12.50 (2)
Other	12.50 (2)
Equity	6.25 (1)
Department	6.25 (1)
School tools	6.25 (1)
Students learning	6.25 (1)
Teachers motivation	6.25 (1)

C. Teachers' expectations from participating

They were also asked for their expectations from participating in the project, and with their answers it was also conducted an inductive thematic analysis from where there were generated 6 categories (see Table 7).

Table 7. Categories of teachers' expectations from participating in the project

Category	Description	Example
Learning	To learn about this methodology (i.e.: understand it, to see the potential, etc.)	T15: *Acquire knowledge and learn about maker methodology*
Applicability	To be able to apply this methodology in their lessons	T12: *Apply these resources in a natural way to any matter and see the potential they offer in primary education.*
Specific learning	To learn specific aspects (i.e.: 3D printer, Scratch, design program, etc.)	T16: *Learn to work with the printer and know the design program*
Prove	To prove the efficacy of the methodology (i.e.: improvement in their students learning, motivation, etc.)	T08: *I hope students learn the old age in a totally different and more motivating way*

Confidence	To feel more confident with the methodology	T09: *More knowledge, confidence and ideas.*
Motivation	To increase their students' motivation	T02: *What the students find motivation and I ideas*

The most common expectation that teachers had was to learn about maker methodology (75.00%, N = 12), followed by a high percentage of people who were willing to be able to apply this methodology in their lessons (37.50%, N = 6) (see Table 8).

Table 8. Percentage of teachers' expectations from participating in the project

Expectation	Participants (%) (N)
Learning	75.00 (12)
Applicability	37.50 (6)
Motivation	12.50 (2)
Specific learning	6.25 (1)
Prove	6.25 (1)
Confidence	6.25 (1)

D. Teachers' statements agreement

The second research question was: **how does it change teachers thought participating in maker activities?** To know this, there were posed different statements to see if their level of agreement changed from before to after participating in the project. The agreement had to be indicated based on a Likert scale which responded to:

0 – Absolutely disagree
1 – Disagree
2 – Neither agree nor disagree
3 – Agree
4 – Absolutely agree

With the results obtained it was conducted a dependent t-test analysis but there weren't any significant changes (see Table 9 and Figure 5).

From the results it can be seen that teachers' perceived ability to design and to conduct maker activities increased after participating in the project, as well as their perceived ability to introduce the maker methodology in their teaching practice throughout the academic year using it in different lessons. It also increased their perception of having enough knowledge about how the technological tools work and how to apply them to be able to introduce them in the classroom, and also having training opportunities to learn more about how the technological tools work and how to apply them in the classroom.

Some factors that decreased were the perception of having sufficient time to design and to conduct an educational lesson using maker tools and activities and about having the ability to introduce them in different subjects. They also perceived that they didn't have the needed material available as much as they thought, as well as they didn't perceive that the organization was giving them support to develop the maker methodology.

Table 9. Teachers' statements' agreement before and after participating in the project

Statement	Before – M (SD)	After – M (SD)	*p-value*
I am able to design an educational lesson using maker tools and activities.	1.86 (1.167)	2.57 (1.089)	0.086
I have the sufficient time to design an educational lesson using maker tools and activities.	2.07 (1.089)	1.93 (0.917)	0.720
I am able to conduct an educational lesson using maker tools and activities.	2.29 (1.326)	2.57 (0.938)	0.525
I have the sufficient time to conduct an educational lesson using maker tools and activities.	2.50 (0.760)	2.14 (1.099)	0.315
I am able to introduce the maker methodology in my teaching practice throughout the academic year using it in different lessons.	2.64 (0.842)	2.79 (0.975)	0.655
I am able to introduce the maker methodology in my teaching practice throughout the academic year using it in different subjects.	2.64 (0.633)	2.57 (1.016)	0.793

I have available the needed material to conduct maker activities (computers, tablets, electronics and robotics components, etc.).	2.64 (1.216)	2.14 (1.167)	0.169
I receive support from the school organization to conduct maker activities.	3.21 (1.122)	3.00 (1.177)	0.568
I know enough about how the technological tools work to be able to apply them in the classroom.	1.79 (0.893)	2.14 (1.099)	0.266
I have training opportunities to learn more about how the technological tools work to be able to apply them in the classroom.	2.50 (1.019)	2.71 (1.139)	0.426
I know enough about how to apply the technological tools in the classroom.	2.07 (0.917)	2.21 (0.975)	0.583
I have training opportunities to learn more about how to apply the technological tools in the classroom.	2.64 (1.082)	2.57 (1.089)	0.793
I have spaces where to share experiences based on the maker methodology with other professionals.	2.00 (1.177)	2.00 (0.877)	1.000

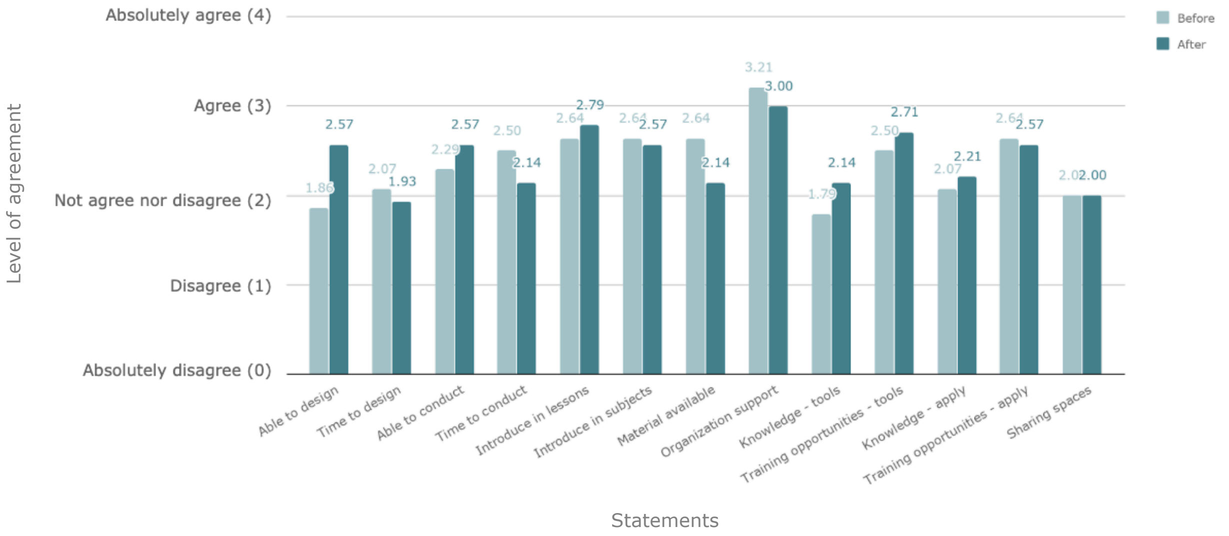

Figure 5. Teachers' statements level of agreement before and after participating in the project

E. Limitations perceived by the teachers

The last research question was: **what does it need to be improved to help teachers to implement maker activities?** To find an answer to this question, they were asked about the limitations that they thought that could face when implementing maker activities as well as the actions that they thought that would be interesting to carry out to address those limitations. They were asked these questions before and after participating in the project to see if their impression changed.

From their answers to the question "What limitations do you think you can face at the moment of applying maker methodologies in the classroom?", there was conducted an inductive thematic analysis and 6 categories were generated (see Table 10).

Table 10. Categories of teachers' perceived limitations

Category	Description	Example
Don't know	They didn't know what limitations they could face.	T14: *Until the moment I find myself facing this challenge, I cannot answer.*
Material	Not having the material needed	T04: *The cost of the material*
Knowledge	Not having the sufficient knowledge	T15: *The limitations that I can find are the lack of knowledge and experience*

Students	The low level of their students, their attitude, etc.	T03: *The level of the students and the little autonomy they have for doing this kind of activities*
Time	Not having enough time for preparing and testing the activities	T07: *To have time to try the activities before.*
Technical problems	To have technical problems (computer, Wi-Fi, etc.).	T12: *The bad working order of technological devices and upgrades for some of them.*

The limitation that prevails the most before and after having participated in the project is the category "knowledge" since nearly half of them think that they don't have the sufficient knowledge. In the post questionnaire everyone detects at least one limitation, and no one puts its focus on the technical problems that could appear. Furthermore, after participating in the project less than before think that students could contribute to have limitations, and there is a biggest amount of people that worries about the time (see Table 11 and Figure 6).

Table 11. Percentage of perceived limitations before and after participating in the project

Category	Before (%) (N)	After (%) (N)
Knowledge	43.75 (7)	53.33 (8)
Material	31.25 (5)	33.33 (5)
Time	6.25 (1)	33.33 (5)
Students	25.00 (4)	13.33 (2)
Technical problems	12.50 (2)	0.00 (0)
Don't know	6.25 (1)	0.00 (0)

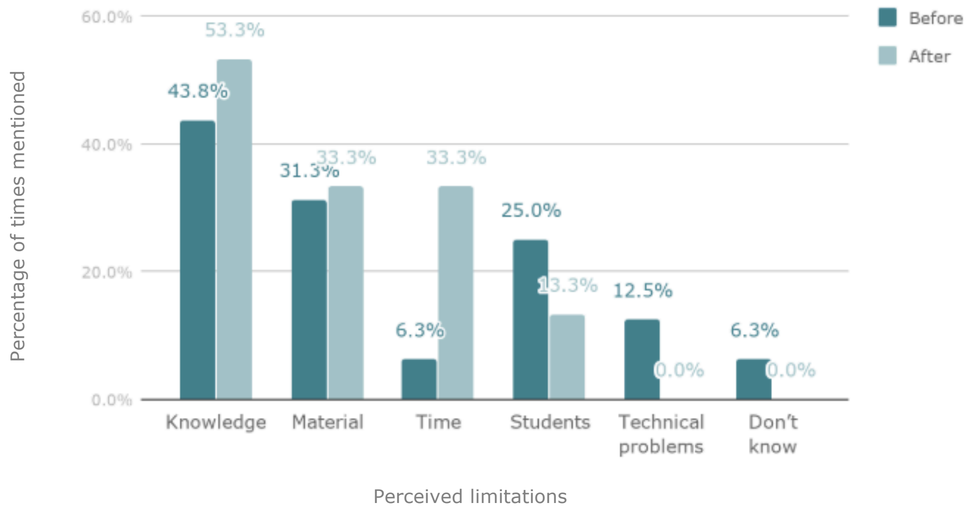

Figure 6. Perceived limitations before and after participating in the project

F. Actions mentioned by the teachers to address the limitations

From their answers given the question "What actions do you think that would be interesting to conduct to address the limitations indicated?", there was also conducted an inductive thematic analysis and 6 categories were generated (see Table 12).

Table 12. Categories of teachers' indicated actions to address the limitations

Category	Description	Example
Don't know	They didn't know what actions would be interesting to conduct.	T17: *I cannot say it until I do this training*
Material	To have the material needed, to receive subventions to buy it.	T09: *Endowments by the Department to buy material*
Training	To receive training about the maker methodology and its practice	T15: *To participate in more trainings and solve doubts.*
Activities	To develop properly planned activities	T07: *Plan and schedule activities very much.*
Support	To receive support from another person, an expert	T15: *To receive support about the use of Scratch or doing some training.*
Time	To have more time to prepare and develop maker activities	T16: *More time in order to prepare the activities and schedule them*

About the actions that should be taken, after finishing the project nearly the double of participants than before think that it would be useful to receive more training. Furthermore, after the project their put more emphasis in the need of having more time to prepare and develop maker activities. As well as in the limitations detected, in this case everyone mentions at least one action that should be taken after participating in the project (see Table 13 and Figure 7).

Table 13. Percentage of actions before and after participating in the project

Category	Before (%) (N)	After (%) (N)
Training	25.00 (4)	46.67 (7)
Material	31.25 (5)	33.33 (5)
Activities	25.00 (4)	13.33 (2)
Time	6.25 (1)	26.67 (4)
Don't know	18.75 (3)	0.00 (0)
Support	6.25 (1)	6.67 (1)

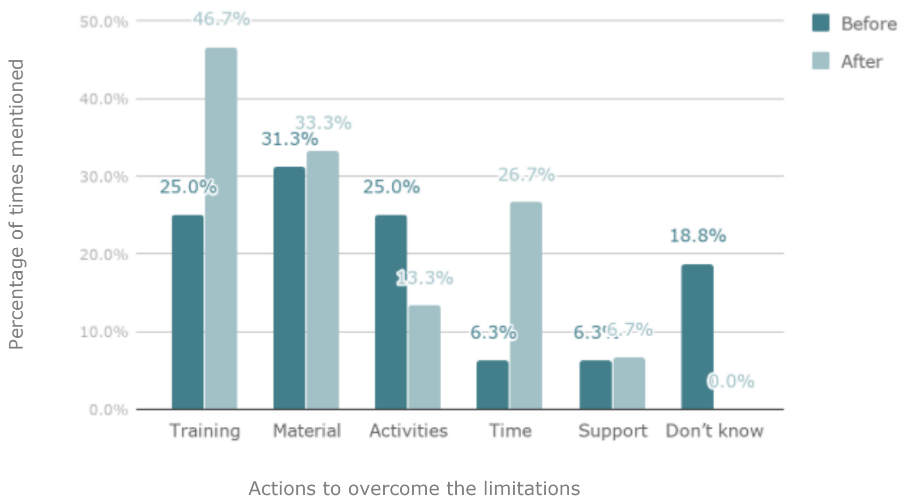

Figure 7. Actions to overcome the limitations before and after participating in the project

G. Teachers' project evaluation

To collect information about the teachers' evaluation of the project, they were asked for their perceived usefulness of the project before and after participating in it. It was analyzed if the change was significant through a dependent t-test, comparting the punctuation given from a Likert scale going from 0 to 3 responding to the following levels of usefulness:

3 – Very useful
2 – Quite useful
1 – Not really useful
0 – Not useful at all

When looking at the perceived usefulness, while the mean valuation before participating in the project was 2.36 (*SD* = 0.497), between "quite useful" and "very useful", the mean after the project was 2.21 (*SD* =0.426), a bit lower but not significant (*M* = 0.143, *SD* = 0.663, t(13) = 0.806, p = 0.435, *CI* [0.526, 0.240], d = 0.21). In conclusion, most people considered the project as quite useful (see Table 14 and Figure 8).

Table 14. Percentage of teachers' perceived usefulness of the project before and after participating in it

Level of perceived usefulness	Before (%) (N)	After
Very useful	31.25 (5)	20.00 (3)
Quite useful	62.50 (10)	80.00 (12)
Not really useful	6.25 (1)	0.00 (0)
Not useful at all	0.00 (0)	0.00 (0)

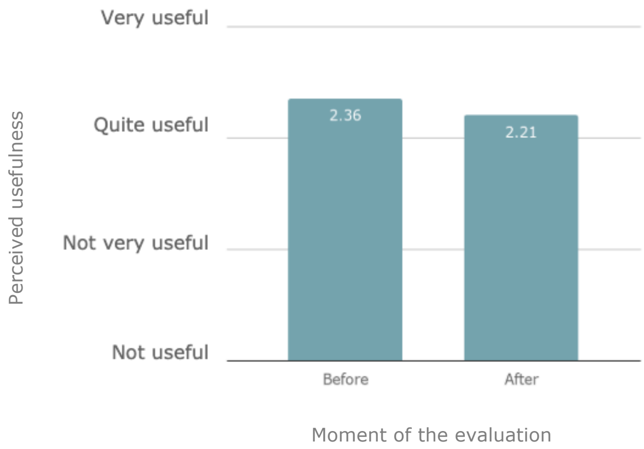

Figure 8. Teachers' perceived usefulness of the project before and after participating in it

Teachers were also asked to highlight a positive aspect of the project, and from the aspects that they mentioned, there was conducted an inductive thematic analysis and 6 categories were generated (see Table 15).

Table 15. Categories about positive aspects mentioned by teachers

Category	Description	Example
Students' motivation	The motivation shown by students.	T14: *How students have been motivated.*
Organization	The good organization of the project, including the communication, the instructors, the material, etc.	T03: *The good work of the instructor; as well as all the didactic material used.*
Teachers' learning	The learning gained by teachers.	T08: *The fact of learning new and good tools to work with them.*
Students' learning	The learning gained by students.	T10: *Everything that students have learned.*
Opportunity	The opportunity given from the project to develop maker activities in schools with low resources.	T02: *Students have the opportunity to start in the programming language in order to create something useful.*
Integration	The possibility to integrate maker activities with other subjects.	T12: *Transversality of the methodology in several areas.*

The positive aspect that was said by most participants was students' motivation, followed by a good organization of the project and the learning that teachers were getting. It was also mentioned students' learning, the fact of giving the opportunity to schools participate in maker activities and the good integration of maker activities with other subjects (see Table 16).

Table 16. Percentage of positive aspects mentioned by teachers

Category	Participants (%) (N)
Students' motivation	26.66 (4)
Organization	20.00 (3)
Teachers' learning	20.00 (3)
Students' learning	13.33 (2)
Opportunity	13.33 (2)
Integration	13.33 (2)

They were also asked to highlight a negative aspect of the project that should be improved. An inductive thematic analysis was conducted generating 6 categories (see Table 17).

Table 17. Categories about negative aspects to be improved mentioned by teachers

Category	Description	Example
Nothing	Nothing negative.	T11: *Nothing. Everything has been perfect.*
Timing	Not enough time.	T12: *Few sessions for children to perform most of the programming by themselves.*
Difficulty	Too high level of difficulty.	T05: *Maybe to make an easier project.*
Support	Receive more support from instructors.	T03: *That two people in the classroom are insufficient for a class of 25 students. They are very dependent, and they need you to give them support at all times.*
Organization	Some bad organization of the project, including the communication, the instructors, the material, etc.	T08: *Maybe the organization.*
Material	Not enough material or material not working properly.	T12: *More material.*

There were some teachers that indicated that there had been nothing negative, some of them mention the time limitation and others found the project chosen too difficult for their students. One person had lacked support from the instructor, another thought that the organization could still be improved and one teacher pointed out that it would be good to have more material so that students don't need to be in groups (see Table 18).

Table 18. Percentage of negative aspects to be improved mentioned by teachers

Category	Participants (%) (N)
Nothing	13.33 (2)
Timing	13.33 (2)
Difficulty	13.33 (2)
Support	6.66 (1)
Organization	6.66 (1)
Material	6.66 (1)

H. Teachers' reported short-term and long-term benefits for students

Teachers were also asked what benefits they thought that doing maker activities could have for their students, in a short-term and in a long-term period.

An inductive thematic analysis was conducted from their answers generating 8 categories (see Table 19). Teachers could say more than one category.

Table 19. Categories about short-term benefits for students

Category	Description	Example
Knowledge of the tool	Getting knowledge about the specific tool that is being used.	T08: *Learn the technique of 3D printing and learn to model in three dimensions their own designs at the same time that they will know the printing process.*
Mental structure	Changing their thinking processes.	T02: The change in the way of organizing their thinking.
Motivation	The motivation these activities generate in students.	T15: *They will get in touch with the new technologies in a very motivating way.*
Field of study	Discover the field of study related to technology and information.	T10: *Open their mind to the informatic and technological environment*

Self-construct	Improvement of their self-construct regarding self-esteem and self-concept.	T09: *Higher self-esteem when they came to finish projects that they were not able to do or did not know they could do.*
Autonomy	Adoption of autonomy.	T09: *Earning autonomy and feeling of "I can do"*
Teamwork	Development of skills regarding teamwork.	T07: *They will work in groups and know a new, highly motivating and innovative work tool.*
Don't know	Don't know what the short-term benefits can be.	T13: *I don't know*

While before participating in the project most persons mentioned a benefit to gain learning about the tool and to change their mental structure, after having participated in the project there was less people that mentioned these benefits. After the project, more people indicated that motivation was a good benefit that evolved from these activities. Furthermore, it was nearly tripled the number of teachers saying that it was a benefit to learn more about this engineering field of study (see Table 20 and Figure 9).

Table 20. Percentage of short-term benefits for students, before and after the project

Category	Before (%) (N)	After (%) (N)
Knowledge of the tool	43.75 (7)	33.33 (5)
Mental structure	43.75 (7)	20.00 (3)
Motivation	18.75 (3)	26.66 (4)
Field of study	6.25 (1)	20.00 (3)
Self-construct	6.25 (1)	13.33 (2)
Autonomy	0.00 (0)	6.66 (1)
Teamwork	6.25 (1)	0.00 (0)
Don't know	6.25 (1)	0.00 (0)

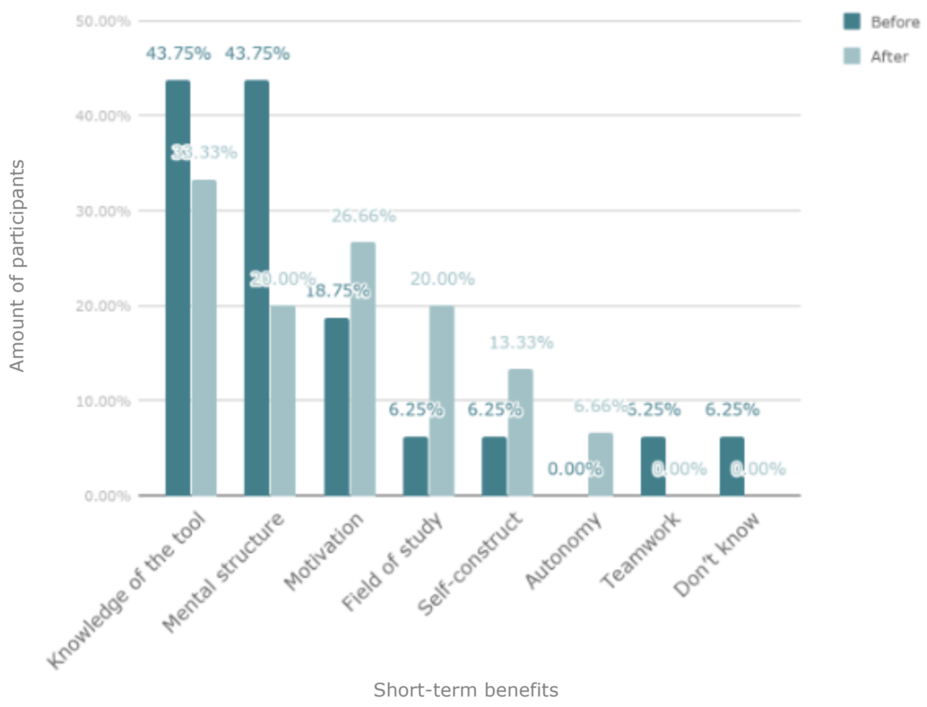

Figure 9. Percentage of short-term benefits for students, before and after the project

Again, through an inductive thematic analysis, 8 categories were generated (see Table 21), teachers could say more than one category.

Table 21. Categories of long-term benefits for students

Category	Description	Example
Mental Structure	Changing their thinking processes.	T06: *Strategies, autonomy, reflections, creativity, critical thinking.*
Knowledge of the tool	Getting knowledge about the specific maker tools.	T13: *Command maker activities.*
Prepared for the future	To be prepared for the future.	T17: *To become people capable to develop with facility in the current society, which is very technological.*
Field of study	Discover the field of study related to technology and information.	T03: *They are given the opportunity to learn about another world; in this case the technological and digital. And who knows, in the future, a boy or girl can be trained or work in this field.*

Learning	Learning of various competencies.	T01: *Expand your knowledge and have more tools for acquiring learning.*
Autonomy	Improvement of autonomy.	T09: *Autonomy when faced with DIY challenges that they will encounter in the everyday life.*
Self-construct	Improvement of their self-construct regarding self-esteem and self-concept.	T09: *Reaffirmation of self and self-confidence.*
Don’t know	Don’t know what the long-term benefits can be.	T13: *I don’t know*

While before participating in the project half of the teachers thought that a change on the mental structure could represent a benefit for their students, there’s less people that says it after having participated in the project. It happens something similar with the thought of preparing their students for the future. It increases the Percentage of knowledge of the tool as a long-term benefit, as well as it also increases the fact of thinking that knowing more about this engineering field of study could help them in their lives and also the fact of learning. Students’ autonomy is a factor that doesn’t have any presence after the project (see Table 22 and Figure 10).

Table 22. Percentage of long-term benefits for students, before and after the project

Category	Before (%) (N)	After (%) (N)
Mental Structure	53.33 (8)	20.00 (3)
Knowledge of the tool	13.33 (2)	26.7 (4)
Prepared for the future	33.33 (5)	20.00 (3)
Field of study	6.66 (1)	20.00 (3)
Learning	6.66 (1)	20.00 (3)
Autonomy	13.33 (2)	0.00 (0)
Self-construct	6.66 (1)	6.66 (1)
Don’t know	6.66 (1)	0.00 (0)

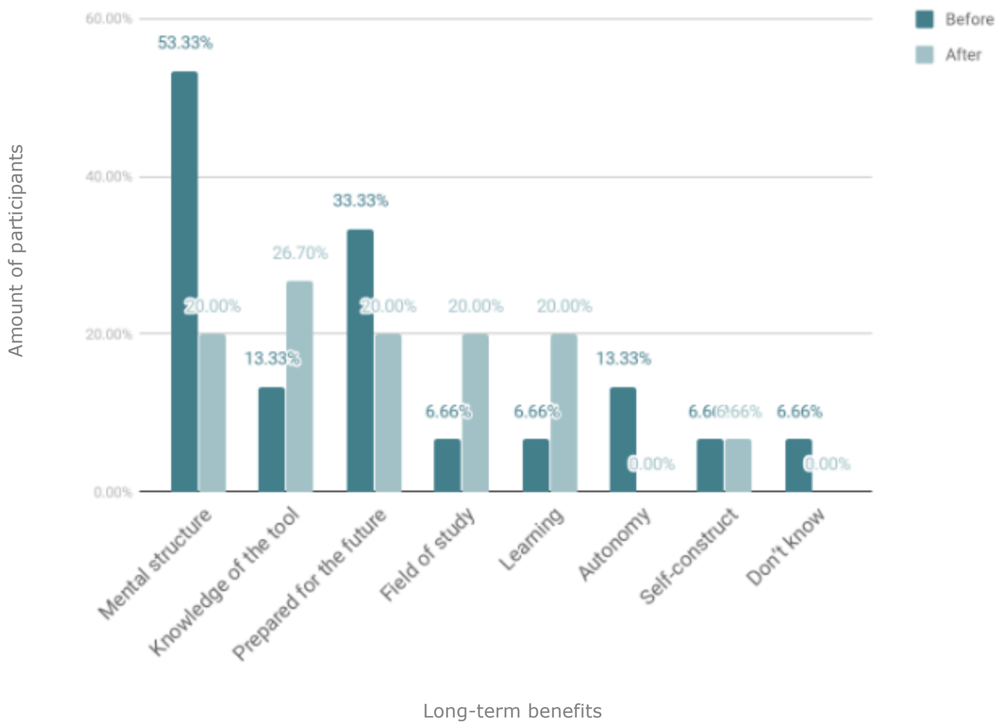

Figure 10. Percentage of long-term benefits for students, before and after the project

3.1.2. Students’ questionnaires results

A total of 243 students from public schools in Barcelona participated in the project Makers a les Aules, but only 239 consented to participate in the study. Nevertheless, only 230 responded the pre-questionnaire and 196 the post-questionnaire.

The sample was gender balanced (girls: 50.21%, N = 120; boys: 46.03%, N = 110; missing: 3.77%, N = 9) (see Figure 11). The students were between 9 and 13 years old (M = 10.24, SD = 1.019) (see Figure 12) and corresponded to the primary levels of 4^{th}, 5^{th} and 6^{th} (4^{th} grade: 41.84%, N = 100; 5^{th} grade: 25.52%, N = 61; 6^{th} grade: 32.64, N = 78).

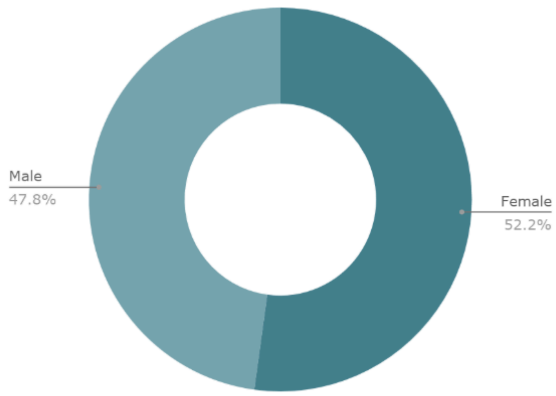

Figure 11. Students' gender distribution

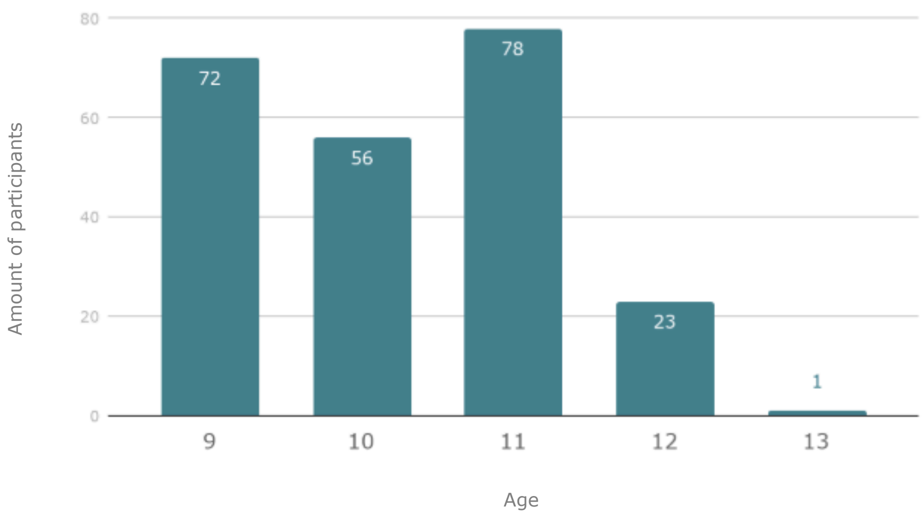

Figure 12. Students' age distribution

A. Students' prior experience

The first research question was: **do they know what maker activities or maker tools are?** In the very first session and after having participated in a presentation about what maker activities are, a 27.95% (N = 64) of the students said that they had heard about maker activities. When looking at differences between genders, there is a nearly significant difference that indicates that boys have heard of maker activities more than girls (boys: 33.9%, N = 37; girls: 22.5%, N = 27; $X^2(1, N = 229) = 3.715$, $p = 0.054$, Ø = 0.127) (see Figure 13).

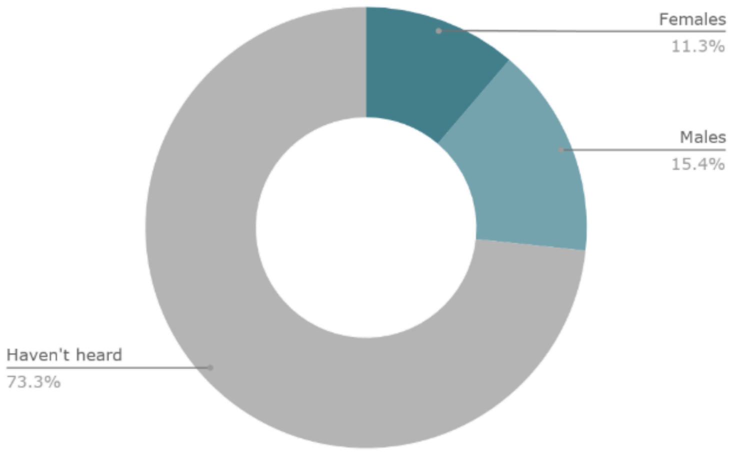

Figure 13. Students that had heard of maker activities differentiated by gender

The main tool that students had already used was Scratch (73.04%, N = 168), followed by Beebot (45.65%, N = 105) and WeDo (40.00%, N = 92). Through an independent t-test it was proved that here weren't any significant differences between genders (see Table 23 and Figure 14).

Table 23. Percentage of students with experience using a specific tool, gender comparison

Tool	Participants (%) (N)	Females (%) (N)	Males (%) (N)	*p-value*
Scratch	73.04 (168)	72.50 (87)	73.64 (81)	0.846
Beebot	45.65 (105)	50.00 (60)	50.22 (45)	0.167
WeDo	40.00 (92)	39.17 (47)	40.91 (45)	0.788
Makey Makey	18.69 (43)	17.50 (21)	20.00 (22)	0.627
Lego Mindstorms	17.39 (40)	13.33 (16)	21.81 (24)	0.090

Snap!	6.95 (16)	5.00 (6)	9.09 (10)	0.223
Microbit	5.22 (12)	4.17 (5)	6.36 (7)	0.454
Makeblock	4.78 (11)	4.17 (5)	5.45 (6)	0.648
Arduino	2.61 (6)	1.67 (2)	3.64 (4)	0.349
App Inventor	1.74 (4)	0.83 (1)	2.73 (3)	0.272
TinkerCAD	1.30 (3)	0.00 (0)	2.73 (3)	0.069
Beetle Blocks	0.87 (2)	0.00 (0)	1.81 (2)	0.138
Colby	0.87 (2)	0.83 (1)	0.91 (1)	0.951

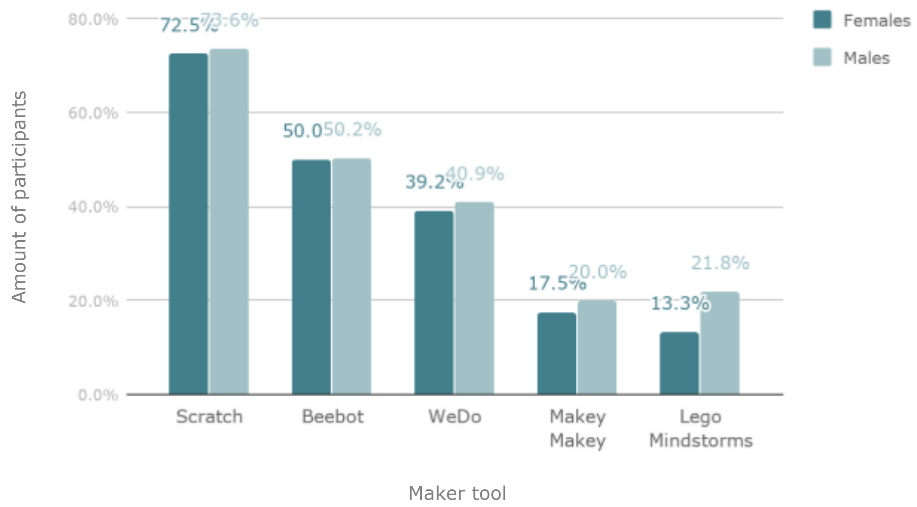

Figure 14. Percentage of students with experience using the five most used tools, gender comparison

About the places where they have used the tools, the main one is at School (73.47%, N = 169) (see Table 24 and Figure 15). In this case, applying a chi-square independent test it was found that there were significant differences between genders regarding the use of maker tools at home being males who had used tools at Home more than females (X^2 (1, N = 230) = 4.293, p = 0.038, Ø = 0.137) and the use of maker tools in a Summer camp, being also males who had used them more (X^2 (1, N = 230) = 5.228, p = 0.022, Ø = 0.151). In both relations there is a weak effect size, meaning that it can't be generalized to the biggest population.

Table 24. Percentage of places where students had gained experience, gender comparison

Place	Participants (%) (N)	Females (%) (N)	Males (%) (N)	*p-value*
School	73.47 (169)	75.00 (90)	71.82 (79)	0.585
Home	23.91 (55)	18.33 (22)	30.00 (33)	0.038*
Academy	10.87 (25)	10.00 (12)	11.82 (13)	0.658
Library	9.13 (21)	12.50 (15)	5.45 (6)	0.064
Friends' home	3.91 (9)	1.67 (2)	6.36 (7)	0.066
Summer camp	3.48 (8)	0.83 (1)	6.36 (7)	0.022*

** Significant p-value, area for further investigation*

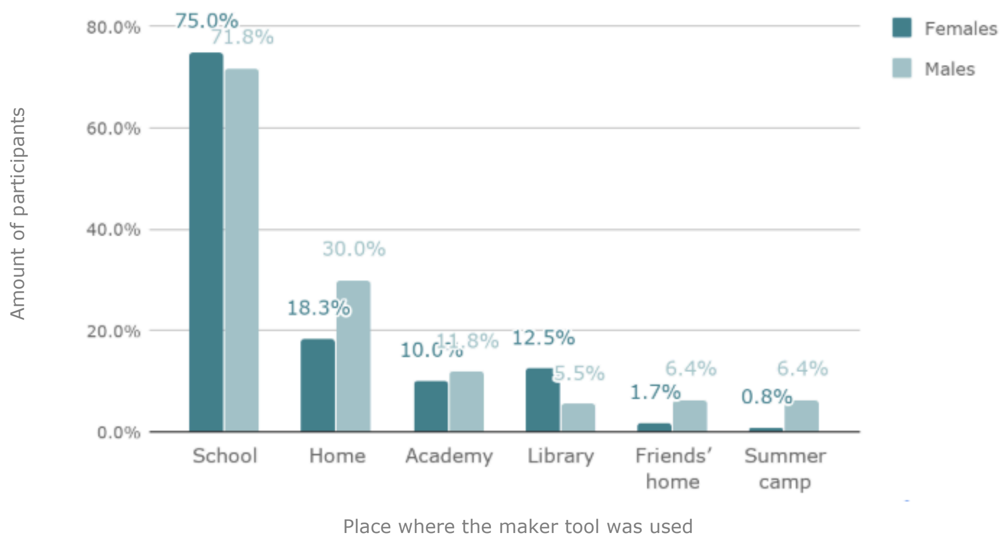

Figure 15. Percentage of places where students had gained experience, gender comparison

B. Students' statements agreement

The second research question was: **how does it change students thought participating in maker activities?** Students had to indicate their level of agreement regarding different statements to see if their agreement had changed before and after participating in the project. The agreement had to be indicated based on a Likert scale which responded to:

0 – Absolutely disagree
1 – Disagree
2 – Neither agree nor disagree
3 – Agree
4 – Absolutely agree

Through the application of a dependent t-test there were found differences between the levels of agreement that students had before and after the project regarding different statements. In all the significant statements, the mean has increased (see table 25 and Figure 16).

- The first one is the thought about being good at technology (M = 0.181, SD = 0.883, t(165) = 2.638, p = 0.009, CI [0.045, 0.316], d = 0.20).
- The second one is the thought of being good at science (M = 0.299, SD = 0.882, t(165) = 4.389, p = 0.001, CI [0.165, 0.434], d = 0.34).
- The third one is the fact of asking or looking for information about maker activities or tools (M = 0.376, SD = 1.277, t(185) = 4.019, p = 0.001, CI [0.192, 0.561], d = 0.29).
- The fourth is about having seen maker activities done by others on the internet (M = 0.301, SD = 1.569, t(185) = 2.618, p = 0.010, CI [0.074, 0.528], d = 0.19).
- The fifth one is about if they have talked about maker activities and tools with friends (M = 0.524, SD = 1.356, t(184) = 5.261, p = 0.001, CI [0.328, 0.721], d = 0.39).
- The sixth about if they have done it with their family (M = 0.602, SD = 1.508, t(185) = 5.447, p = 0.001, CI [0.384, 0.820], d = 0.40).

Table 25. Students' statements' agreement before and after participating in the project

Statement	Before – M (SD)	After – M (SD)	*p-value*
I think I am good at technology.	2.72 (0.864)	2.90 (0.916)	0.009*
I think I am good at science.	2.09 (0.930)	2.39 (0.993)	0.001*
I think I am creative.	3.16 (0.855)	3.03 (0.987)	0.084
I think I am good at doing maker activities.	2.69 (0.925)	2.65 (1.016)	0.630
I am able to do maker activities alone.	2.05 (1.090)	2.24 (1.153)	0.085
I like doing maker activities.	3.55 (0.854)	3.43 (0.897)	0.120
I have asked/looked for information about maker activities and/or tools.	1.01 (1.050)	1.39 (1.172)	0.001*
I have seen maker activities done by others in the internet.	1.52 (1.312)	1.82 (1.433)	0.010*
I have talked about maker activities and/or tools with my friends.	1.12 (1.117)	1.64 (1.226)	0.001*
I have talked about maker activities and/or tools with my family.	1.20 (1.278)	1.81 (1.431)	0.001*

** Significant p-value, area for further investigation*

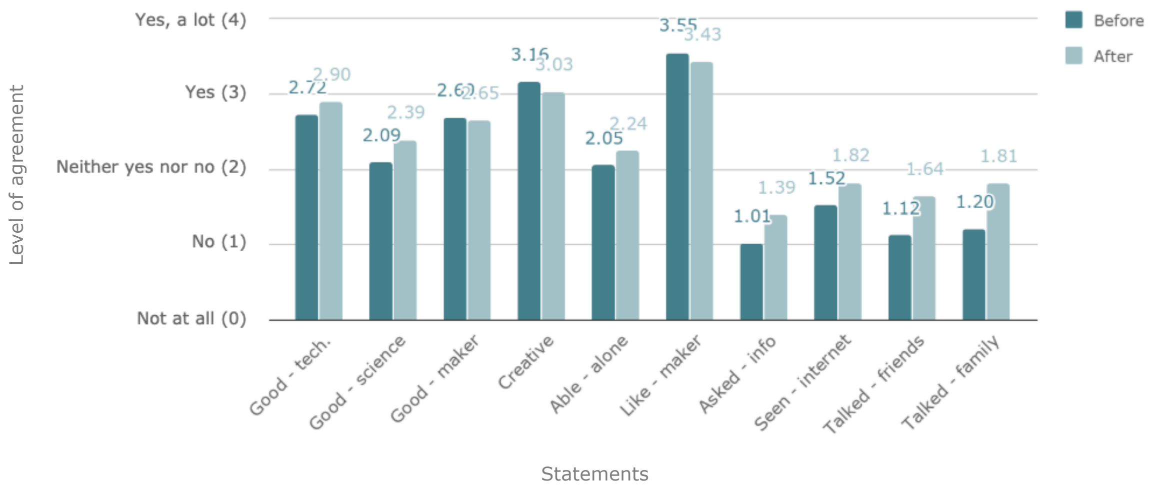

Figure 16. Students' statements' agreement before and after participating in the project

It was also contrasted the effect of the project between genders to see if it was different for males and females.

In the case of females what changed is that the fact of having seen maker activities in the internet was not significant (see Table 26).

Table 26. Female students' statements' agreement before and after participating in the project

Statement	Before – M (SD)	After – M (SD)	*p-value*
I think I am good at technology.	2.56 (0.783)	2.80 (0.855)	0.003*
I think I am good at science.	2.03 (0.930)	2.34 (0.950)	0.001*
I think I am creative.	3.15 (0.873)	3.09 (0.984)	0.614
I think I am good at doing maker activities.	2.62 (0.971)	2.63 (1.000)	0.926
I am able to do maker activities alone.	2.03 (1.121)	2.22 (1.207)	0.137
I like doing maker activities.	3.57 (0.881)	3.51 (0.839)	0.547
I have asked/looked for information about maker activities and/or tools.	1.03 (1.061)	1.29 (1.143)	0.022*
I have seen maker activities done by others in the internet.	1.63 (1.298)	1.83 (1.463)	0.185
I have talked about maker activities and/or tools with my friends.	1.10 (1.048)	1.62 (1.211)	0.001*
I have talked about maker activities and/or tools with my family.	1.24 (1.279)	1.89 (1.448)	0.001*

** Significant p-value, area for further investigation*

In the case of males, the statement regarding being good at technology didn't change significantly, while the fact of believing to be creative changed significantly showing an agreement decrease (see Table 27).

Table 27. Male students' statements' agreement before and after participating in the project

Statement	Before – M (SD)	After – M (SD)	*p-value*
I think I am good at technology.	2.91 (0.920)	3.03 (0.973)	0.320
I think I am good at science.	2.16 (0.933)	2.44 (1.043)	0.009*
I think I am creative.	3.18 (0.839)	2.96 (0.993)	0.034*
I think I am good at doing maker activities.	2.78 (0.861)	2.68 (1.041)	0.413
I am able to do maker activities alone.	2.09 (1.056)	2.27 (1.089)	0.224
I like doing maker activities.	3.52 (0.823)	3.32 (0.960)	0.114
I have asked/looked for information about maker activities and/or tools.	0.99 (1.042)	1.51 (1.203)	0.001*
I have seen maker activities done by others in the internet.	1.37 (1.323)	1.80 (1.403)	0.018*
I have talked about maker activities and/or tools with my friends.	1.14 (1.201)	1.67 (1.250)	0.001*
I have talked about maker activities and/or tools with my family.	1.16 (1.283)	1.70 (1.412)	0.002*

** Significant p-value, area for further investigation*

C. Students’ most liked things

Regarding what students liked the most from the project, it was conducted an inductive thematic analysis of participants’ answers and from there were generated 16 categories (see Table 28).

Table 28. Categories of students' most liked things

Category	Description	Example
Everything	They liked everything from the project	S105: *I have liked everything*
Nothing	They didn’t like anything from the project	S136: *Nothing*
Tool	They liked the specific tool used in the project (Scratch, Makey Makey and Tinkercad or 3D printer)	S127: *I have liked Tinkercad, Makey Makey and the 3D printer*
Computer	They liked to use the computer and its devices such as the microphone	S179: *To use the computer because I have learned new things*
Teamwork	They liked the fact of working in groups and/or they group	S145: *I have liked to be with my group*
First session (experimentation)	They mention that they liked the first session, without specifying the reason why they do. Most of them experimented with the tool in the first session.	S109: *The first session*
Design Thinking process	They liked some of the phases of the Design Thinking such as ideation (thinking what to do), prototyping and designing	S147: *To design our future toy with plasticine and in the computer*
Programming	They liked the fact of programming with Scratch	S167: *The thing about programming*
Crafts	They liked doing crafts (ex: painting, making shapes with cardboard, etc.)	S100: *What I have liked the most has been to decorate the pizza boxes with paint*
Create	They liked to create something by their own	S150: *That you can create everything you think about*
Final Product	They liked the final product that they had produced	S059: *What I liked the most was when we did the videogame*

Topic	They liked the topic worked	S151: *What I have liked the most is the (theme about) not for boys nor girls*
Learn	They liked the fact that they were learning	S072: *What I have liked the most has been to learn things I didn't know about makers*
Fun	They liked the fact that it was fun	S200: *Everything, because it is very funny*
Customizable	They liked to have the option to customize their final creations	S082: *That we could personalize our project*
Other	They liked other uncategorizable items	S037: *The makers*

The category that was mentioned the most was "Tool" regarding the different tools that each student had used, followed by the Design Thinking process such as the phases of ideate, prototype, etc. (see Table 29 and Figure 17).

To see if there were any significant differences between genders it was conducted an independent t-test, showing that there weren't any significant differences.

Table 29. Percentage of students' most liked things, gender comparison

Category	Participants (%) (N)	Females (%) (N)	Males (%) (N)	*p-value*
Tool	30.73 (59)	30.69 (31)	30.49 (25)	0.976
Design Thinking process	27.60 (53)	26.47 (27)	29.63 (24)	0.636
Everything	9.89 (17)	12.87 (13)	4.88 (4)	0.064
Final Product	8.33 (16)	6.93 (7)	9.76 (8)	0.488
Teamwork	5.73 (11)	6.93 (7)	3.66 (3)	0.333
Learn	5.73 (11)	6.93 (7)	4.88 (4)	0.561
Computer	5.21 (10)	2.97 (3)	8.54 (7)	0.099
Programming	5.21 (10)	2.97 (3)	8.54 (7)	0.099
Crafts	4.17 (8)	4.95 (5)	2.44 (3)	0.378
First session (experimentation)	1.66 (3)	0.99 (1)	2.44 (2)	0.443
Fun	1.66 (3)	1.98 (2)	1.22 (1)	0.687

Create	1.56 (3)	1.98 (2)	1.22 (1)	0.687
Customizable	1.04 (2)	0.99 (1)	1.22 (1)	0.882
Topic	1.56 (3)	1.98 (2)	1.22 (1)	0.687
Other	1.04 (2)	0.99 (1)	1.22 (1)	0.882
Nothing	0.52 (1)	0.99 (1)	0.00 (0)	0.366

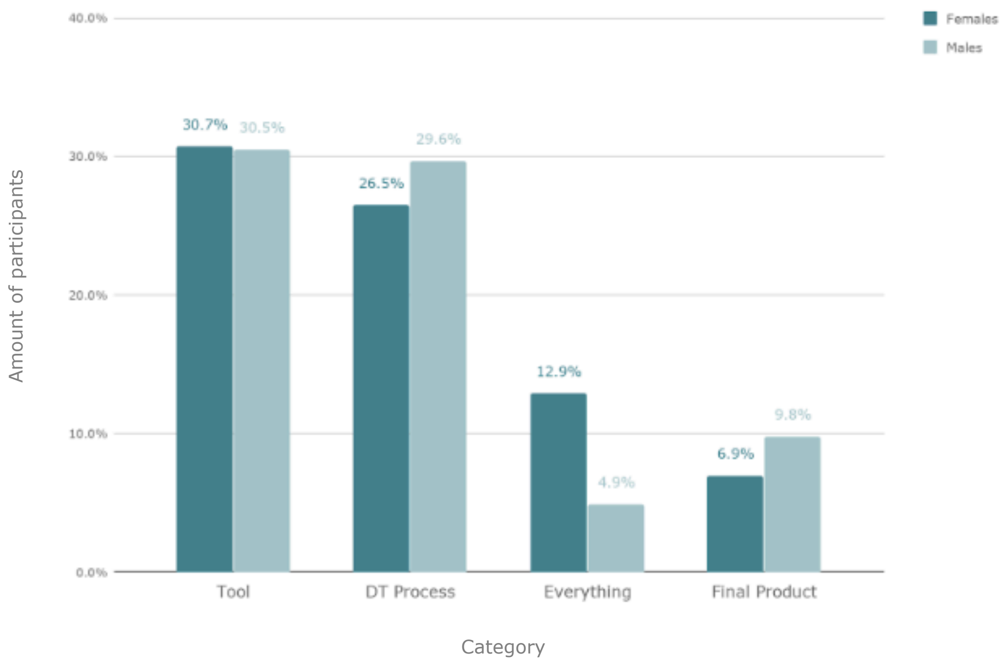

Figure 17. Five most liked things said by students, gender comparison

D. Students' least liked things

In relation to what they liked the least from the project, it was also conducted an inductive thematic analysis of participants' answers and from there were generated 18 categories (see Table 30).

Table 30. Categories of students' least liked things

Category	Description	Example
Nothing	There was nothing that they didn't like from the project	S090: *I have liked everything we have done*
Anything	They didn't like anything from the project	S136: *Everything*

Don’t know	They didn’t know if there was something that they didn’t like	S191: *I don’t know*
Theory	They didn’t like the initial theory explained	S013: *The explanation of the instructions*
Tool	They didn’t like the tool used	S128: *Scratch*
Few lessons	They didn’t like the fact that there were few lessons	S004: *That there haven’t been may lessons*
Design Thinking process	They liked some of the phases of the Design Thinking such as ideation (thinking what to do), prototyping an designing	S134: *When we had to design*
Technical problems	They didn’t like the fact of having technical problems (computer, Wi-Fi, etc.)	S025: *That our computer was not working*
Classmates	They didn’t like the fact that their classmates were talking, their teamwork, etc.	S175: *That people who knew better, had more (time) the computer*
Make presentations	They didn’t like the fact of doing a presentation in front of the rest of the class	S131: *To do the presentation*
Final product	They didn’t like the final product that they had created	S151: *To create a toy of the future.*
Easy	They didn’t like the fact that it was too easy	S052: *When I did things that I already knew*
Difficult	They didn’t like the fact that it was too difficult	S150: That it is a bit difficult to create something
Crafts	They didn’t like doing crafts (ex: painting, making shapes with cardboard, etc.)	S109: *To do the pencil*
Searching	They didn’t like to have to search for information before doing the activity	S104: *When we only looked for information*
Frustration	They didn’t like to have problems while doing it and feeling frustrated	S125: *That it didn’t work*
Topic	They didn’t like the topic	S145: *The topic about girls and boys*
Other	They didn’t like other uncategorizable items	S204: *What I have liked the least is that I missed to go to one lesson*

Nearly half of the students said that there wasn't anything that they hadn't liked. Some mentioned the theory explanation, the tool or the dynamic generated with their classmates (see Table 31 and Figure 18).

Through the application of an independent t-test, there weren't found any significant differences.

Table 31. Percentage of students' least liked things, gender comparison

Expectation	Participants (%) (N)	Females (%) (N)	Males (%) (N)	*p-value*
Nothing	45.35 (83)	47.37 (45)	40.51 (32)	0.364
Theory	6.56 (12)	7.37 (7)	6.33 (5)	0.788
Tool	6.56 (12)	7.37 (7)	6.33 (5)	0.788
Classmates	5.46 (10)	7.37 (7)	3.79 (3)	0.314
Difficult	4.92 (9)	4.21 (4)	6.33 (5)	0.530
Few lessons	3.28 (6)	4.21 (4)	2.53 (2)	0.546
Technical problems	3.28 (6)	1.05 (1)	5.06 (4)	0.115
Frustration	2.73 (5)	3.16 (3)	2.53 (2)	0.806
Final product	2.18 (4)	1.05 (1)	3.80 (3)	0.229
Crafts	2.18 (4)	1.05 (1)	3.80 (3)	0.229
Easy	1.64 (3)	1.05 (1)	0.00 (0)	0.360
Don't know	1.64 (3)	1.05 (1)	2.53 (2)	0.456
Other	1.64 (3)	0.00 (0)	3.79 (3)	0.055
Topic	1.09 (2)	2.10 (2)	0.00 (0)	0.195
Design Thinking process	1.09 (2)	11.11 (11)	8.00 (6)	0.494
Make presentations	1.09 (2)	1.05 (1)	1.27 (1)	0.895
Searching	1.09 (2)	1.05 (1)	1.27 (1)	0.895
Anything	0.55 (1)	1.05 (1)	0.00 (0)	0.360

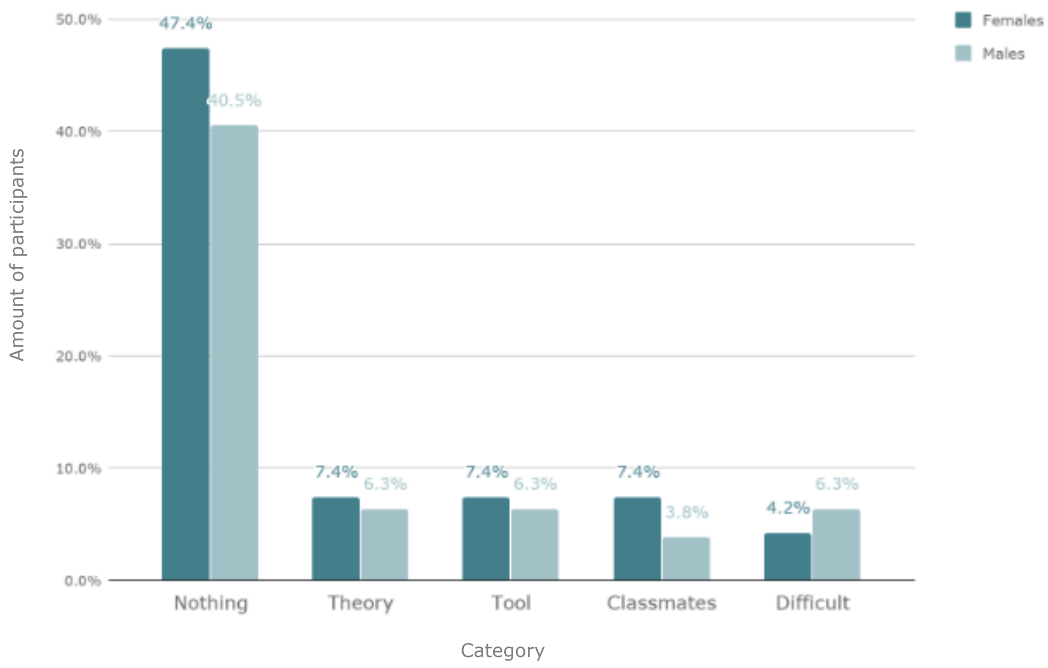

Figure 18. Five least liked things said by students, gender comparison

E. Students engagement

To see if they were engaged, they were asked if they would like to do more "maker activities" and the results indicate that most of them say that "yes" or "yes, a lot" (M = 3.35, SD = 0.890). Through the application of an independent t-test, there weren't found any differences regarding the responses that females and males gave ($t(185) = 0.497$, $p = 0.620$, CI [0.196, 0.328]) (see Table 32 and Figure 19).

Table 32. Students' engagement, "would like to do more maker activities", gender comparison

Would you like to do more maker activities?	Participants (%) (N)	Females (%) (N)	Males (%) (N)
Not at all	1.53 (3)	1.94 (2)	1.19 (1)
Not	2.04 (4)	1.94 (2)	2.38 (2)
Neither yes or no	12.75 (25)	15.53 (16)	10.71 (9)
Yes	27.55 (54)	26.21 (27)	31.95 (26)
Yes, a lot	56.12 (110)	54.37 (56)	54.76 (46)

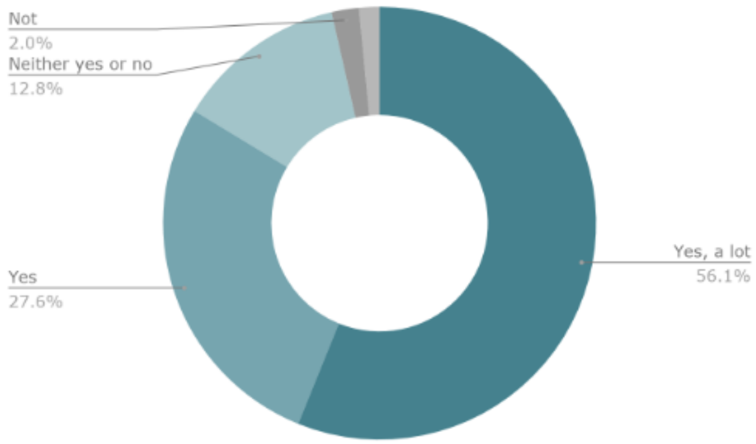

Figure 19. Students' engagement, "would like to do more maker activities"

F. Students maker self-concept

It was also measured if they were feeling themselves as "makers" and most of them agreed that "yes" they were feeling so (*M* = 2.63, *SD* = 1.027). Through an independent t-test there weren't found any differences between females and males ($t(185) = 0.681$, $p = 0.497$, *CI* [0.197, 0.404]) (see Table 33 and Figure 20).

Table 33. Students' maker self-concept, gender comparison

Do you feel yourself a maker?	Participants (%) (N)	Females (%) (N)	Males (%) (N)
Not at all	3.06 (6)	3.88 (4)	2.38 (2)
Not	9.69 (19)	8.74 (9)	11.90 (10)
Neither yes or no	30.10 (59)	33.01 (34)	27.38 (33)
Yes	35.20 (69)	35.92 (37)	33.33 (28)
Yes, a lot	21.94 (43)	18.45 (19)	25.00 (21)

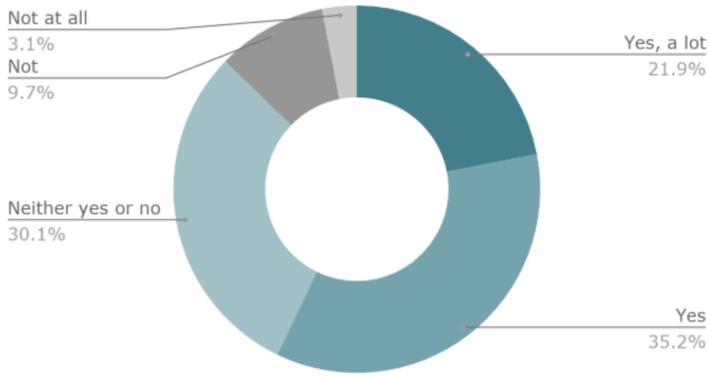

Figure 20. Students' maker self-concept

G. Students' project evaluation

Finally, nearly all students indicated to have liked or liked a lot having participated in the project Makers a les Aules. There was applied an independent t-test and there weren't found any differences between females and males (t(185) = 0.850, p = 0.397, *CI* [0.319 0.316]) (see Table 34 and Figure 21).

Table 34. Students' evaluation of the project, gender comparison

Have you liked “Makers a les Aules”?	Participants (%) (N)	Females (%) (N)	Males (%) (N)
Not at all	0.51 (1)	0.97 (1)	0.00 (0)
Not	0.51 (1)	0.97 (1)	0.00 (0)
Neither yes or no	12.24 (24)	11.65 (12)	14.28 (12)
Yes	32.65 (64)	28.15 (29)	39.29 (33)
Yes, a lot	54.08 (106)	58.25 (60)	46.43 (39)

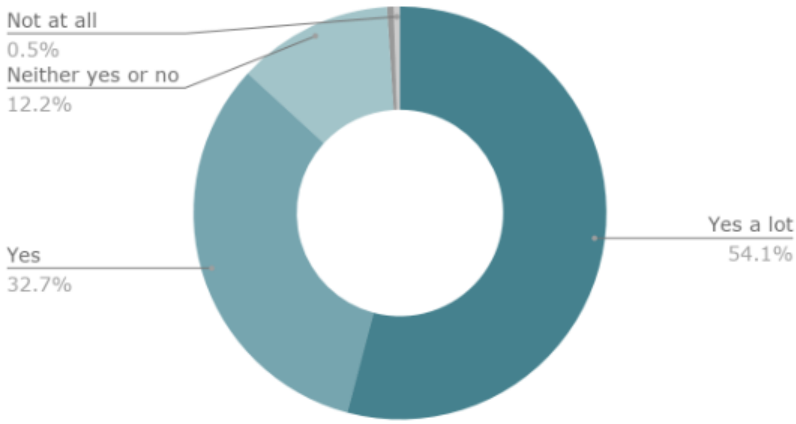

Figure 21. Students' assessment of the project

3.2. Observations

One school was randomly selected as a case study to perform observations in their lessons. The school selected was a High Complexity Center, which means that has students that need special attention mainly because of coming from immigrant families.

In this school the group was working with Makey Makey in the topic of Geography, by creating an interactive map (see Figure 22). The students were between 11 and 12 years old, they corresponded to a 6th grade in a high complexity school. There were organized in six groups of students working each of them in a different continent. There was one main teacher and also two teachers that were assisting occasionally.

Figure 22. Interactive maps and Makey Makey

In the first session the students were presented to the Makey Makey tool, they could learn what it was, how it worked, and they could experiment with it. In the second lesson they were given the first instructions to elaborate the program with Scratch, they were introduced to the programming language through the instructions given by the instructors. In the third lesson, they continued working on the Scratch program by also following the instructions. In the fourth lesson they connected their program to the map through a Makey Makey. The map was already prepared from other lessons not related to the program.

Continuedly, there are presented the teachers' and the students' observations. All the observations were done by the main researcher and contrasted with the instructor.

3.2.1. Teachers' observations

From the teacher's observation, there could be extracted three main themes: participation, rapprochement to the tool and learning (see Table 34). The different themes corresponded to the following definition:

- **Participation**: participation in the class, observable functions developed.
- **Rapprochement to the tool**: involvement in the teaching of the maker tool, interaction with the tool when working with students.
- **Learning**: expression of having learned something new, repetition of what has been learned to students, confidence to explain something to students.

From the beginning, the teaching of the class was transferred to the instructor and the teacher covered other functions. Its participation in the lessons was mainly associated with arranging the different groups of students, giving them the material needed (computers), solving technical problems (computers that weren't working, low WIFI connection, etc.), and interacting with students to both encourage them to keep doing the good work and to calm them down in order to maintain an appropriate classroom atmosphere.

While during the two first sessions they tried to help students to learn how to use the tools, Makey Makey and Scratch, his participation regarding maker aspects was diminished in the last two sessions where they were mainly looking at what students were doing.

About aspects that could be seen to be learnt, there were techniques used by the instructor that they acquired to better explain a concept to students. They were also more confident to help students to connect the Makey Makey as well as to find some specific blocks on

Scratch after having seen the specific explanation of the instructor. They also expressed to have learned the function of sending messages to other characters in Scratch.

Table 35. Teachers' observations

Theme	Session 1	Session 2	Session 3	Session 4
Participation	Solved technical problems. Gave the material needed to students. Helped students to understand the conductivity concept.	Gave the material needed to the students. Helped students when they have questions about Scratch. Verbally rewarded students and encourage them. Modulated the noise in the class.	Solved technical problems. Organized group distribution. Didn’t interact in the explanations done by the instructor. Verbally rewarded students and encourage them.	Solved technical problems. Modulated the noise in the class. Didn’t interact in the explanations done by the instructor.
Rapprochement to the tool	They were confident to help students connecting the tool (Makey Makey) to the computer. They could easily navigate in the Scratch platform.	Helped students to find some programming blocks but didn’t participate in the explanation of the tool.	Tried to help students that ask for help about Scratch but expressed that she didn’t know how to help them and asked for help to other students. In another situation, helped effectively the group also in relation to Scratch.	They didn’t go into technical details, just listened and observe.

Learning	A teacher shown expressions of learning a way of explaining the concept of conductivity and this made her able to help students to understand it.	Any new learning observed. They related the new concepts taught to children with another educational technology, the robot WeDo.	Payed attention to new features of Scratch unknown for her and repeated it to a specific group that asks for it. She learns this new feature.	Any new learning observed.

3.2.2. Students' observations

From the students' observations there could be extracted 6 themes: attention, interest and motivation, participation, difficulties, impatience and learning (see Table 35). The different themes corresponded to the following definitions:

- **Attention**: level of attention of students, amount of time looking at the teacher or at the tool that has to be used when the instructor indicates it, silence in the class when they are supposed to be listening.
- **Interest and motivation**: questions asked, willingness to continue working on the project, own motivation to work on the project without the need of asking them to do so.
- **Participation**: observable level of participation in the class and in the group, answering questions, work on the required task.
- **Difficulties**: expressed problems or difficulties related to the tool or any other issue that could hamper the development of the lesson.
- **Impatience**: expressed need to know what to do after each step.
- **Learning**: expression of being surprised by something new that has been learned, demonstrated ability to apply something new to their Scratch program or ability to make the connections of the Makey Makey successfully.

The level of attention of the students changed throughout the sessions. In the second session, when they were introduced to the Scratch program, they didn't pay attention to the instructor in different occasions. In the first and third sessions they were paying a lot of attention to the instructor, and in the last one they focused only on their project.

They showed interest in all the sessions and were motivation to work on the project. They used to ask questions about Scratch features that were not being presented, in order to implement them on their project and improve it. They were participative in all the sessions, the fact of customizing their own program made them to be actively working on the project. A part of following the instructions from the instructor, they were constantly exploring the site.

Students showed themselves impatient when finishing the steps that were indicated because they wanted to know what to do next. When this situation was given, they started browsing the Scratch platform. In the last session they weren't that impatient, since they could be working more autonomously on their projects.

Most of them didn't present relevant difficulties. The difficulties that appeared were related to the connection of the Makey Makey and to finding specific Scratch blocks. In the last session they were able to solve the rising questions within themselves. There were two students who had difficulties with understanding the language in some situations.

About what was seen to be learned, in all the sessions they were learning and applying new concepts regarding Makey Makey or Scratch. Regarding Scratch, they expressed to connect previous learning that had acquire from another educational technology tool, WeDo, to the new concepts that were learning from the programming language. They were also asking questions to learn some aspects that weren't taught.

Table 36. Students' observations

Theme	Session 1	Session 2	Session 3	Session 4
Attention	They payed close attention to the instructor.	It was harder for them to pay attention to the explanation of the instructor.	They were again paying a lot of attention to the instructors.	Paying attention to their own group, they were working more autonomously.
Interest and motivation	Surprise reactions when experimenting with the tool (Makey Makey), some of they were asking where they could buy one Makey Makey.	Interested to explore the platform Scratch by themselves. They asked to know more about the possibilities they have with the tool.	Interested about recording their voices in their animation.	They liked to improve their creation. They wanted to expand their project and introduce other features, but they don't have more time to do so.

	They tried the tool very interested on it.	They shared with the other groups their knowledge and achievements.		
Participation	They answered the instructor's questions and ask some questions as well very often. They tried the tool very interested and curious.	They followed the instructions and also explore other functionalities of Scratch. They customized their animation.	They just followed the instructions without having any questions. They also customized their animation.	Everyone as very participative in the group, adding the features they can to their project.
Impatience	Wanted to know what they were going to do after each task. Impatient to use the Makey Makey and to know to what website to go.	When they had done one step, they wanted to know which was the next one.	Again, they were impatient to know what to do after the current step.	They didn't expressed impatience. They had questions but while waiting for answers, continued patiently working on their project.
Difficulties	It was hard for them to understand how to connect the Makey Makey to the conductive material used (Play-Doh).	They didn't present any specific difficulties, they follow the steps. In some occasions, it was difficult for them to find some blocks in Scratch.	They found difficulties related to language issues, instructions given in Spanish and Scratch in Catalan. It was difficult for them to find some blocks in Scratch.	If they had any difficulties related to Scratch features, they solved them within themselves.

Learning	They are surprised of knowing how conductivity works, and about the fact that water is conductor. They learn how to connect the Makey Makey.	They ask for new features such as changing the size of their character (working the percentage concept) and finding a vector image without background.	In general, they show themselves more confident in using the programming blocks. One group refers to the programming language to the educational technology tool WeDo when looking for a way to implement a delay.	They learned the features about voice recording.

3.3. Interviews

Since the instructors had been the ones that followed and kept track of the workshops in the different schools, there were carried out an interview with one of them (I1) and another one with the other two together (I2 and I3).

A semi-structured interview was used for this purpose. Different themes were explored related to the effect of the project on teachers and on students, the attitudes that it was promoting, general aspects of the project and improvements that they thought that could be made.

Regarding the effect on teachers, there are different themes that could be extracted from their explanations (see Table 36):

- **Motivation**: level of motivation of teachers in the class and throughout the different lessons.
- **Participation**: participation of the teachers in the classroom in relation to the teaching of the maker tool and the development of the maker project.
- **Previous knowledge**: expression of teachers' previous knowledge and its implication.
- **Continuity**: possibility of continuity observed from teachers.

From the beginning, the instructors reported having seen differences in the different schools, due to different factors, some of them unidentifiable.

In general, they detected that teachers were motivated along the sessions, but having some previous experience with the tools used, such as Scratch, made teachers' motivation more visible.

About participation, in some schools, teachers were participating only to organize the class and the students without going into detail about the maker tools, whereas in other schools the teachers were more proactive in relation to the maker tools. Some of the teachers that were more proactive had previous knowledge, but there were some that didn't have any previous knowledge but asked to the instructor what they needed to know in order to help students.

About the intention to continue developing maker activities, one of the instructors reported that teachers shown intentions to do so, since some of they asked for information about how to buy the devices used (Makey Makey) and also expressed that they could use Scratch their daily practice.

Table 37. Effect on teacher themes

Effect on teacher themes	Examples
Motivation	I1: *high motivation, the teacher would try to continue it in the class.* I3: *Teacher had previous knowledge of scratch, very good, he was very motivated.* I3: *They would need more knowledge to be more motivated, for example, to know Scratch (through previous training).*
Participation	I1: *Teachers were encouraged to do the initial explanation but didn't use the tools.* I2: *It depends on the attitude, in a school they did not know how to handle Tinkercad. In others they tried to help, they were not afraid, they had a proactive attitude.* I2: *Generally, very happy with the participation* I3: *There was a school where the teachers were motivated from the beginning, everything was prepared at the beginning of the sessions. They helped with Scratch and if they did not know something, they asked me (the instructor). This is transmitted to the students* I3: *In a school there was not good participation, the reason may be because they did not know the technology.*

Previous knowledge	I3: *A teacher learned Scrach, had prior knowledge but learned more in the process.* I3: *Another teacher had previous knowledge of scratch, very good, he was very motivated.*
Continuity	I1: *They were very motivated to continue.* I1: *She had the intention to buy some Makey Makey.* I1: *They may use Scratch.*

There are also different themes that came from their valuations on the effect it had on students (see Table 37):

- **Motivation**: level of motivation of students in the class and throughout the different lessons.
- **Learning maker-related concepts**: detection of students' learning.
- **Connection to the transversal topic**: observed effective connection of the maker activity developed with the topic worked.

About students, instructors reported that most of them had shown a high level of motivation regarding their level of implication in the topics treated, as well as the willingness to improve the maker product that they were creating. Nevertheless, in some cases, the level of motivation decreased along the sessions, maybe because the content got to be repetitive.

In relation to their learning, one instructor reported to see improvements regarding knowledge about electronic and programming concepts. The other also agreed, adding that they had the feeling that students had learned more about the main transversal topic and not only about maker related aspects.

Furthermore, it was seen by the instructors that the projects that were well connected to the transversal topic worked better than the ones that weren't.

Table 38. Effect on student themes

Effect on student themes	Examples
Motivation	I1: *They wanted to modify the program, add the voice, they were motivated to keep improving it* I2: *Making the project was a form of stimulation to work on the topic initially agreed.* I3: *The students were losing their motivation, perhaps this was related to the design of the workshop, since in subsequent sessions they did not see anything new and were not that motivated. Maybe it should be designed so that there would be introduced new concepts in each session.*
Learning maker-related concepts	I3: *Very visible improvement regarding concepts of electronics and programming.*
Connection to the transversal topic	I1: *They were already working the prehistory, but this helped them to deepen and share the information among their mates.* I2: *The cases that it was well related to the class syllabus and not isolated or abstract, worked better.* I3: *They improved their knowledge in the subject content such as the water cycle.*

Regarding the overall Project, there are some remarkable themes (see Table 38):

- **Lack of time**: insufficient time to develop the projects.
- **Lack of control**: noisy atmosphere insufficiently controlled by the teacher.
- **Different rhythms**: students had different rhythms when doing different tasks.
- **Students organization**: the way that students were organized had implications on the development of the project.
- **Age**: the age of students could affect the development of the project.

In general, it was seen that it would have been good to have more time to develop the project, since it was insufficient to finish everything that was planned to develop in some the projects.

On the other hand, regarding the development of the project in the class, one instructor thought that there wasn't enough control from the teacher regarding the students. Furthermore, the fact that students had different rhythms of work, difficulted to keep the planned track of the sessions.

About the students' organization it was seen that a good distribution was to put them in pairs, rather than in bigger groups. Lastly, the age of the students was also mentioned as an important factor, since it was seen that for the youngest ones some projects were too difficult but for the oldest ones some projects weren't enough motivational

Table 39. Overall project themes

Overall project themes	Examples
Lack of time	I1: *They were out of time.* I3: *Insufficient time to develop the designed projects.*
Lack of control	I1: *The teacher should have kept more the climate in the classroom, draw the attention of the students.*
Different rhythms	I1: *Some students were disconnected from the class, worked on their own, were more advanced than their mates.*
Students' organization	I2: *We worked in groups of 3-4, with a computer per group, and in general it worked well but in certain groups it was difficult.* I3: *In most of the schools the students worked in pairs, and this worked better than in groups of 4 because it is difficult to distribute computers and Makey Makey between 4 people. Couples is what works best.*
Age	I2: *Age influences how students get involved, with the youngest in 4th level, it was more difficult follow the rhythm (and that they remember what they had done in other sessions) with the older ones is easier to follow the rhythm of the sessions. Younger children need more sessions (or perform more closed in time).* I3: *Age affects motivation, the older students were less motivated.*

Some improvements that were mentioned can be grouped in different themes as well (see Table 39).

- **More instruction hours**: there would be needed to have more hours with the teacher to instruct them.
- **More hours in class**: there would be needed to have more hours with students in the class.

It was reported by all the instructors that it would be good to have more hours at the beginning of the project to explain the teacher how the different tools work and to plan the projects that would be carried out.

Furthermore, it would also be good to have more hours in class with the students to develop the projects.

Table 40. Improvement themes

Improvement themes	Examples
More instruction hours	I1: *It would be nice to be able to have more hours, maybe the double (4h) at the beginning to plan the sessions with the teachers and for them to be able to learn the tool better.*
More hours in class	I1: *Those who could not finish in the lesson did it throughout the week in free class hours, maybe they did 4-8 hours more than the ones marked in the project.* I3: *5 sessions are few sessions in general. Having 6 sessions would be better.*

4. Discussion

4.1. Discussion regarding teachers

The majority of the teachers were females with a mean of 40 years old. Only one third of the sample had previous experience, for some of whom it was frequent to implement the maker methodology once a week or once a trimester. About the tool used, all of the teachers with prior experience had used Scratch, and the majority had used as well Beebot and WeDo. Most of them had used them in mathematics, and there were some that had done it in a subject focused on programming. For all of them, the experience of using the maker methodology was good or really good. It was reported by the instructors that when teachers have prior knowledge, they feel more confident to participate actively in the class and interact with the maker tools.

Regarding the first research question, **the reasons that drove them to participate in the project were not specifically related to the reasons why it is important to develop maker activities in the classroom** due to previous literature (to develop the 21st century digital skills[9,34,35] and to increase students' interest and self-perception in relation to the STEAM fields[34,35,37]). For half of the them their motivation to participate in the project was to innovate in their lessons, without specifying the reason why they thought that it is important to innovate or what do they exactly mean with innovation. Some of them also wanted to do it to promote equity within students and to integrate the maker methodology in their lessons, something that been previously proved as effective[28,29]. To do so, a big part of the sample expected to learn about the maker methodology and some of the teachers expected to see how they could apply it in their lessons.

About the changes on teachers' thoughts after participating in maker activities and regarding the second research question, despite there weren't found any statistical differences, **their perceived ability to design, conduct and introduce maker activities in different lessons and subjects, increased after having participated in the project**. Furthermore, after the project, they reported to know better how the tools and how to apply them in the class, something is related to previous studies that have found that teachers feel more confident to implement and create maker activities for their lessons after having received training about it[18,24]. Finally, after the project they agreed more than before with the believe of having training opportunities to keep improving their knowledge about the tools

Nevertheless, what they realized after participating in the project was that they didn't have sufficient time to design nor to conduct maker activities, as well as that they didn't agree with having available the material needed, receiving enough support from the school or having enough opportunities to learn how to apply the methodology in the lessons.

Furthermore, and in relation with the third research question, while before the project there were some teachers who didn't know what limitations they could face, after the project everyone knows at least one limitation. This change shows an increment of their awareness allowing them to better define the problems and to try to solve them afterwards.

About the perceived limitations, as it was assumed, they mentioned that **their lack of knowledge could be a limitation** and they actually mentioned, in a higher level after the project, that training would be a good action to carry out; something related to the lack of professional development seen in previous studies[39]. Something that we get from the instructors' report is that this lack of knowledge could make teachers feel less motivated or participative in the lessons. Some of them were learning during development of the project, but maybe not enough to start having an active behavior. Nevertheless, they were motivated to continue learning, as seen in the observations where the teacher was interested in hearing the explanations of the instructor, but not feeling yet confident enough to help students with the tools.

A limitation that increases after the project is the perceived lack of time, they realize that they will need more time than the time they have to prepare and develop maker activities. This is why to overcome this problem they propose that the organization should permit to have more time to do so. This fact, related to the fact that they realized they don't receive sufficient support from the organization, could be happening due to a lack of institutional vision, already seen in previous research[39].

After the project, they also keep seeing but in a lower level that a limitation could be the lack of material; the same amount of people thinks that an action that would be taken would be to buy the material needed or ask for monetary help from the department to do so. As seen in previous literature, this limitation would be related to the access problems that teachers face regarding maker activities[39].

Other perceived limitation that decreases after the project is the fact that the lack of knowledge from students would be a problem. Maybe they realize that they have a better level of autonomy than what they thought and a fast capacity for learning. In the case observed, there were some situations where teachers asked students to help their mates, accepting that students knew better than them some aspects and showing confidence on them to teach their peers.

Teachers highlighted their students' motivation while doing maker activities, and they saw it as short-term benefit. Other benefits that they thought that students could have in the short-term were the knowledge of the tool, the discovery of a new field of study and a change on their mental structure. In the long-term, they also added that doing maker activities would allow students to be prepared for their future, among other benefits.

Most of them indicated that the workshop had been quite useful, but their valuation of usefulness decreased few points after participating in the project. As reported by them, some were expecting more practice with the tool, and as it has been already mentioned, they also agreed that a good improvement would be to have more hours of instruction with them. Nevertheless, all the teachers indicated that they would recommend to other teachers to participate in the project Makers a les Aules.

About its continuity, instructors reported having seen interest from the majority of teachers to continue doing maker activities. Some of them were interested in buying some of the tools used, and others just said that they could try to implement Scratch that is free.

4.2. Discussion regarding students

The sample of students was gender balanced, their mean age was 10 years old. About their previous experience and in relation to the first research question, **only a quarter of the sample had heard about maker activities**, but as it was expected, most of them had used Scratch like in previous literature[34], and nearly half of them had used Beebot and WeDo.

In relation to the second research question, there are some changes in the students' agreement with some statements.

There are different aspects that increase after having participated in the project. **Students improve their self-perception in relation to being good at technology and at science**, something that has been already seen improved in previous studies where maker activities were developed[34]. Instructors report that they could realize the learning that students were gaining in relation to electronical concept, and to the main topic that was being treated, proving the effective connection between the tools and the topic. They were also learning different concepts from different subjects such as natural sciences (water) and mathematics (coordinates).

Another aspect that increased was their self-perception about being able to do maker activities alone. It was also observed that **students were gaining autonomy throughout the sessions**, ending up being able to focus all their attention in working in their project as well as helping within them. It has been seen in previous literature that doing maker activities makes participants gain confidence with it[34].

After the project, they also reported to have looked for information about maker activities and having seen some in the internet in a higher rate than before. Furthermore, they had also talked about it with friends and family, something that could be showing an **increment of their interest regarding maker activities**. This was already seen in previous studies where it was proved that introducing maker activities and improving students' knowledge about robotics and programming, increased their interest in STEM[38,40].

At the end, most of them say that they would like to do more maker activities, they become engaged with maker activities. They mentioned that the thing that they had liked the most was the tool used or the Design Thinking process followed. Nevertheless, their attention changed throughout the lessons being at the beginning more focused on the instructor's explanations and at the end focused on their own projects.

Also, a third part of the sample says that they feel a maker, demonstrating the maker mindset that they had develop as happened in previous studies[35]. Furthermore, nearly all of them liked having participated in the project.

Regarding the third research question, **there were found significant differences between genders regarding their previous experience**, since more boys than girls had used maker tools at home and nearly only boys had used them in a summer camp. This could be related to what has been found in previous studies where boys report to have more prior knowledge than girls[30]. Nevertheless, there weren't any differences related to their attitudes about technology, something that had been previously seen thanks to the application of the right conditions when doing maker activities[31].

4.3. Conclusions

Since few studies that have been able to explore how to integrate the maker methodology into primary education environments, and especially in Europe, this is why this thesis offers a novel approach.

Through the exploratory research done in this project, it has been seen that some assumptions that were based on previous literature, have been accomplished.

Few teachers and nearly all students had prior experience using maker tools, concretely, the programming language Scratch. All the students with prior knowledge had gained it at School, what leads us to the important role that school plays in relation to bringing the maker methodology to children and developing the 21st century digital skills associated with it. Teachers participating in the project were willing to learn how to introduce this methodology in their classroom to innovate in their lessons.

It is important to take into account the differences found between genders regarding their prior experience, since boys have more prior experience than girls using maker tools in specific contexts, but all of them report the same level of enjoyment when doing maker activities.

The project had positive effects on all the participants. On the one hand, teachers increased their perceived knowledge and ability to design and develop maker activities in the classroom. On the other hand, students increased their interest and their self-perceived efficacy in technology, and they also increased their level of autonomy doing maker activities. Some limitations that teachers could face for developing maker activities are the lack of knowledge, access to the material and time. As reported by the teachers, actions should be carried out to overcome these limitations such as receiving more training on maker methodologies, acquiring more material and trying to have more time to design and develop maker activities. Given the benefits that the maker methodology can have on students, it is important to continue working on the introduction of this methodology in the classroom.

4.4. Limitations and future directions

We must first take into account that the Makers a les Aules project was a predefined project not created for research purposes.

Because of the fact that the project was done in a real context, the fact of having different projects being developed in each school, based on different topics, with different instructors, and in a different time of the day and course period, supposes a limitation for the study. Furthermore, some changes that were observed cannot be directly related to the project since some other factors could have contributed. To better analyze the effect of developing maker activities, all these factors should be controlled trough the design of a unique activity for all the participants, with the same methodology, duration and led by the same instructor in all cases.

About the data collection it was only possible to observe one single-case and to conduct interviews with the instructors. In further studies it would be interesting to observe more than one case and to conduct interviews with both teachers and students to better understand their answers. Furthermore, the data collected was mainly subjective, coming from the participants' opinions. In future studies it would be useful to evaluate not only their self-perception but their learning and understanding in relation to maker concepts, for this reason there should be introduced some objective measures such as tests or projects evaluations.

Furthermore, a second researcher should be considered for the categorization of the participants' answers, as well as for the observations' conclusions, to get more consistent information from the data collected.

Regarding the limitations perceived by the participants, it has been asked to the organization of the project to extend the number of sessions and total hours in future editions. It would be good to see if having more time for a previous training with teachers has positive effects on them, for instance, incrementing their confidence and rapprochement to the tool in the class. Since the role of the teachers was quite passive regarding the instructors' report, in future iterations of the project it will be tried to give them a more active role. It would be good to see if it has even more positive effects on them.

5. List of figures

6. List of tables

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8. Appendices

8.1. Appendix 1: Teachers’ questionnaires

8.1.1. Teachers’ pre-questionnaire

Google forms link to the teachers’ pre-questionnaire:
https://forms.gle/MW7oQWFbKmaq4JgJ7

8.1.2. Teachers’ post-questionnaire

Google forms link to the teachers’ post-questionnaire:
https://forms.gle/Ju4Af6FTrCWB9PWS6

8.2. Appendix 2: Students' questionnaires

8.2.1. Students' pre-questionnaire

Nom i cognoms: ____

Makers a les Aules

En aquesta enquesta hauràs de respondre a unes preguntes. Tingues en compte que:

- Has de respondre les preguntes de manera ordenada
- Has de donar respostes sinceres, dient la veritat
- No hi ha respostes correctes o incorrectes
- No direm les teves respostes a ningú!

1. Parla'ns de tu!

1.1. Quina edat tens? _______ anys

1.2. Ets...

- ☐ Noi
- ☐ Noia

1.3. A quina escola vas? ____________________________________

2. Les activitats maker

2.1. Havies sentit a parlar alguna vegada d'activitats maker?

- ☐ Sí
- ☐ No

2.2. Quines eines o aplicacions de la llista has fet servir? Pots triar més d'una opció.

- ☐ Scratch
- ☐ Makey Makey
- ☐ Snap!
- ☐ App Inventor
- ☐ Beetle Blocks
- ☐ TinkerCAD
- ☐ Lego Mindstorms
- ☐ Beebot
- ☐ Colby
- ☐ WeDO
- ☐ Arduino
- ☐ Microbit
- ☐ Makeblock

2.4. On vas utilitzar aquestes eines? Pots triar més d'una opció.

- ☐ A casa
- ☐ A casa d'un amic o d'una amiga
- ☐ A l'escola
- ☐ A una biblioteca
- ☐ A un casal / campus
- ☐ A una acadèmia de programació i robòtica

3. Què en penses?

3.1. Fes una creu al quadrat que correspongui segons el que tu **creguis**.

	Gens! ☹️	**No** 😕	**Ni sí, ni no** 😐	**Sí** 🙂	**Sí, molt!** 😁
Crec que se'm dóna bé la **tecnologia**.					
Crec que se'm dóna bé la **ciència**.					
Crec que sóc **creatiu/va**.					
Crec que sóc/puc ser molt **bo/bona** fent activitats maker.					
Crec que puc fer activitats maker tot **sol/a**.					
M'agrada o m'agradaria fer activitats maker.					
Alguna vegada he **demanat/buscat informació** sobre actititats i/o eines maker.					
Alguna vegada he **vist a internet** activitats maker que ha fet la gent.					
Alguna vegada he parlat sobre activitats o eines maker amb els meus **amics i amigues**.					
Alguna vegada he parlat sobre activitats o eines maker amb la meva **família**.					

Moltes gràcies!!

8.2.2. Students' post-questionnaire

Nom i cognoms: ____

Makers a les Aules

En aquesta enquesta hauràs de respondre a unes preguntes. Tingues en compte que:

- Has de respondre les preguntes de manera ordenada
- Has de donar respostes sinceres, dient la veritat
- No hi ha respostes correctes o incorrectes
- No direm les teves respostes a ningú!

1. Què t'han semblat els tallers?

1.1. T'han agradat els tallers de "Makers a les Aules"? Fes una creu al requadre corresponent.

Gens! ☹️	No 😕	Ni sí, ni no 😐	Sí 🙂	Sí, molt! 😁

1.2. Què és el que **més** t'ha agradat dels tallers? Escriu-ho dins del requadre.

1.3. Què és el que **menys** t'ha agradat dels tallers? Escriu-ho dins del requadre.

1.4. T'agradaria fer **més activitats maker** al llarg del curs? Fes una creu al requadre corresponent.

Gens! ☹️	No 😕	Ni sí, ni no 😐	Sí 🙂	Sí, molt! 😁

1.5. Et sents un/a **maker**?

Gens! ☹️	No 😕	Ni sí, ni no 😐	Sí 🙂	Sí, molt! 😁

2. Què en penses?

2.1. Fes una creu al quadrat que correspongui segons el que tu **creguis**.

	Gens! ☹️	**No** 😕	**Ni sí, ni no** 😐	**Sí** 🙂	**Sí, molt!** 😁
Crec que se'm dóna bé la **tecnologia**.					
Crec que se'm dóna bé la **ciència**.					
Crec que sóc **creatiu/va**.					
Crec que sóc molt **bo/bona** fent activitats maker.					
Crec que puc fer activitats maker tot **sol/a**.					
M'agrada fer activitats maker.					
Alguna vegada he **demanat/buscat informació** sobre actititats i/o eines maker.					
Alguna vegada he **vist a internet** activitats maker que ha fet la gent.					
Alguna vegada he parlat sobre activitats o eines maker amb els meus **amics i amigues**.					
Alguna vegada he parlat sobre activitats o eines maker amb la meva **família**.					

Moltes gràcies!!

8.3. Appendix 3: Observation Grid

Observations

Date	
Session	
School	
Observer	

Student
Attention
•
Interest and motivation
•
Participation
•
Difficulties
•
Frustration
•
Impatience
•
Learning
•

Teachers
Interest and motivation
•
Participation
•
Confidence - rapprochement (to the methodology, tool)
•
Learning
•
Influence of previous experience
•
Role - functions
•