Digna Couso Lagarón & Carme Grimalt-Álvaro (Editors)

STEM is for you

Experiences in raising self-efficacy from the STEAM4U project

Co-funded by the Erasmus+ Programme of the European Union

STEAM4U

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EXPERIENCES IN RAISING SELF-EFFICACY FROM THE STEAM4U PROJECT

Universitat Autònoma de Barcelona
Bellaterra, 2019

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Raising self-efficacy in STEM education to provide opportunities for all

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STANCE ON STEM, A MATTER OF INTEREST

Anyone working on STEM education, either at formal or informal level, has faced the challenge of trying to engage a participant who feels that "STEM is not for them". And this person could be sitting next to someone who shows true STEM enthusiasm even before the activity starts. What is different between these two people in the audience? How the same STEM activity could be perceived so differently? We have coined the term "stance on STEM" to refer to the way a person thinks, feels, talks and acts about STEM, that is, their position on STEM-related topics, agents and activities. Stance on STEM encompasses how students see themselves in this field, including their views on what role STEM plays in their life and what role they play in the STEM field (Couso, 2017). This complex construct is the result of past and present experiences on STEM, including educational ones but not only those. Stance on STEM is also a strong influencer of future expectations regarding the STEM field. In psychological and sociological terms, we consider stance on STEM to be based on and the result of one's interests, aspirations, self-efficacy, capacity and identity about STEM (Figure 1). All these variables are interrelated in complex ways, conforming the stance on STEM that our students hold.

Traditionally the idea of "stance on STEM", despite not coined as such, has been approached through the study of the different variables in Figure 1: interest in STEM topics, identity in STEM, aspirations regarding the STEM work field and capacity and perception of capacity in STEM. These studies have proved the existence of differences and inequalities in young people, according to gender, socio-economic background and ethnicity, which would ultimately condition their stance on STEM.

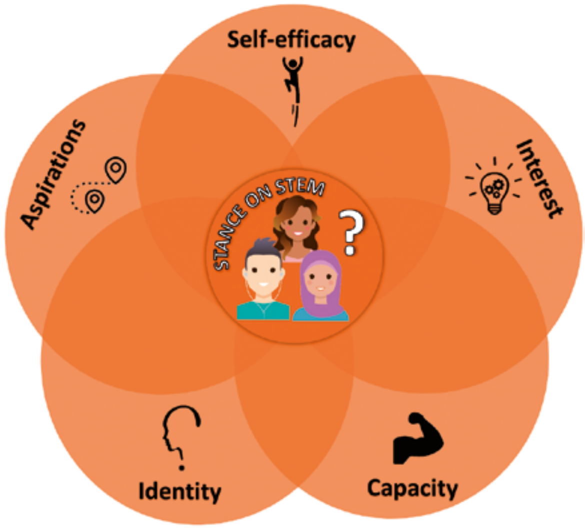

Figure 1. Representation of the factors affecting stance on STEM

For example, regarding interest, although at the age of 10 students' interest in STEM is relatively high with little gender differences (Archer et al., 2010), their interest declines sharply in the following years as they progress through school (Osborne, Simon, & Collins, 2003). This decrease is especially pronounced for girls (Barmby, Kind, & Jones, 2008), which at the age of 14 appear to be generally less engaged by STEM topics (Tytler, Osborne, Foundation, & Forgasz, 2008), especially the ones related with technology and physics (Sjøberg, 2002; Tytler et al., 2008).

Similar results can be found in the literature regarding aspirations in STEM , which appear to be deeply gendered, ethnic and socioeconomic biased: for example, girls envisage themselves as health or biology professionals more than boys do; and boys see themselves as becoming computing (ICT) professionals, scientists (especially physicists) or engineers more than girls do (Bøe & Henriksen, 2013; OECD, 2016b; Sadler, Sonnert, Hazari, & Tai, 2012; Sáinz, 2017); boys in highly deprived schools are more likely to choose mechanics over engineering; among girls, architects, vets and engineers are more popular in less deprived schools, whereas hairdresser, nurse and beauty assistant are more popular professions in the more deprived areas (Chambers, Kashefpakdel, Rehill, & Percy, 2018).

Regarding identity, research has proved the existence of a negative and biased stereotype of STEM professionals which depicts them as white and brainy males, who come from middle-class backgrounds and who are geek, socially awkward and singularly obsessed with their chosen STEM field, which makes them have an almost non-existant personal life (Archer et al., 2013; Kim, Sinatra, & Seyranian, 2018). This stereotyped image has changed little since the 70's well-known study "Draw a scientist" project, and affects negatively students when considering their choices to become STEM professionals. Of course, there are few students who in spite of not identifying with this image, can manage to build their own identity in STEM regardless of this shared and well-known stereotype. However, it is the existence and the strong presence of this STEM stereotype that can explain why very few students, particularly girls and students from socially deprived areas, do not contemplate becoming a STEM professional, despite expressing their liking for STEM topics and themes during school years (Archer et al., 2010). In these authors' research ideas such as " I am not brainy enough" or "this is not for girly girls like me" are powerful messages that emerged often and explained the non STEM career choices of many girls.

Finally, in relation to capacity and believes regarding own capacity (self-efficacy beliefs), there is also consistent evidence that, regardless of their actual capacities, students from underrepresented groups in the STEM field tend to undervalue their own performance and STEM competences (OECD, 2008). For example, although international tests such as PISA show small differences in boys' and girls' competences in STEM, especially for Science (OECD, 2016a), it has been extensively reported that girls assess their science and mathematical abilities much lower than do boys with similar achievements both at school level (Bøe & Henriksen, 2013; Hill, Catherine, Corbett, & St. Rose, Andresse, 2010) and at career or more advanced level (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). In other words, boys and men tend to be more confident than girls and women in their capacities in the STEM field (Schunk & Pajares, 2002). A similar situation happens regarding students with low socio-economic status: research consistently report a strong relationship between low level of socioeconomic background and lower feelings of self-efficacy, in comparison with counterparts with high-socioeconomic level (Archer, Dawson, DeWitt, Seakins, & Wong, 2015; Bandura, 1993; Becker, Kraus, & Rheinschmidt-Same, 2017). In relation to ethnicity, there are no concluding studies whether this variable affects separately to students' self-efficacy, since much of the research has confounded ethnicity with social class by comparing white children of middle socioeconomic levels with ethnic minorities from lower socioeconomic levels (Schunk & Pajares, 2002). However, what research has already shown is that ethnicity would reinforce the negative effect of other variables such as gender and/or socioeconomic level on self-efficacy. In other words self-efficacy among Black undergraduate women is significantly lower than those of their White women peers —a finding not evident for Black men (Ro & Loya, 2015).

SELF-EFFICACY: A CRUCIAL FACTOR FOR A POSITIVE STANCE ON STEM

In the last decade a growing attention has been paid to the critical role of self-efficacy believes in the students' development of their stance on STEM. Research has provided evidence that self-efficacy beliefs deeply configure students' perceptions about their personal value for STEM or not, affecting not only their interest and aspirations, but also their actual capacity. In this sense, we consider self-efficacy believes to be a crucial factor for a positive stance on STEM.

What are exactly self-efficacy believes in STEM? As defined by Bandura (1995), self-efficacy believes refer to the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations. When focused in STEM, we use self-efficacy in STEM to refer to beliefs in one's capabilities to accomplish a particular STEM-related task at a designated level. Self-efficacy believes in STEM, like in other areas, have shown to be different that the real capacity for accomplishing a particular STEM task.

Self-efficacy believes in STEM have an strong impact: the higher students' perceive their own efficacy, the greater the interest they have in STEM activities, and the wider the career options they seriously consider to pursue (Bandura, 1993). This is not surprising considering the strong effect that self-efficacy believes can have in actual performance. In this sense, literature shows that self-efficacy beliefs are a strong predictor of academic performance (Aurah, 2013).

Despite self-efficacy believes can be affected by social stereotypes, self-efficacy beliefs, which are future-oriented (i.e. I know I will be able to do it), are personally built through experience. In other words, these expectations are in large part results of self-schemes that are created from earlier experiences (i.e. I know I will be successful because I have successfully carried out similar tasks before) (Bong & Skaalvik, 2003). Since they are the result of the self-interpretation of multiple past experiences, self-efficacy beliefs tend to be deeply rooted in one's own mind and are difficult to be changed, pointing out a need to undertake and combine multiple strategies and experiences of achievement to successfully change them. Moreover, these features also highlight the need to undertake these actions at early ages in which self-schemas are in initial stages of formation. The older a student is, the more informed and rooted their self-schemas will be and the more difficult it will be to change their perceptions about their own capacities.

Again, people from underrepresented groups in STEM and those not aligned with the STEM stereotype tend to systematically underestimate themselves in STEM-related tasks, compared to their peers. This is related with feeling less interested, holding fewer aspirations and actually performing worse, so it is not surprising that they consider they are not good enough for STEM and that STEM is not for people like them. The consequence is a negative stance on STEM that causes their progressive detachment from STEM activities, which ultimately would imply to drop out of compulsory STEM education at the very first opportunity, and avoiding STEM-related tasks, leisure and information. This affects not only their future prospects in the STEM work force but, more importantly, their likeability to acquire an adequate STEM literacy. In the post-truth knowledge-based, global and post-industrial society in which these students will become full citizens, a poor STEM literacy will act as a severe agent of social exclusion.

4 STRATEGIES TO RAISE SELF-EFFICACY: PROVIDING OPPORTUNITIES FOR ALL IN THE STEAM4U PROJECT

As any deeply rooted belief, self-efficacy believes cannot easily be changed with short-term and superficial actions. This is not to say that self-efficacy cannot improve: we can help all students think they can successfully participate in STEM activities and that they are the right people for doing so. Following this line of reasoning, the STEAM4U project (https://steam4u.eu) draws from a desire to contribute to provide opportunities for all. In the project, we have carried out several actions addressed to change young people's self-efficacy beliefs in STEM, joining the effort of 7 different organisations in formal and non-formal educational from 5 EU countries: (Belgium, Italy, Poland, Spain and Ireland). In STEAM4U, different actions addressed to 10-14-year-old students were undertaken, serving as examples of the bringing into practice of the different strategies that can be used for having a positive impact on self-efficacy. The framework used to justify these actions proposes four families of strategies to address self-efficacy believes in STEM (Figure 2). These four main families of strategies have been constructed combining the previous works of Pajares, (2006), Barry J. Zimmerman & Campillo (2003), Barry J. Zimmerman & Cleary (2006) and choosing the most relevant results and ideas for formal and informal STEM education. They include:

- Facilitating the self-regulation of students before, during and after the STEM activity
- Ensuring that all students can be successful learners in a STEM activity
- Building up a good STEM classroom environment
- Stimulating positive influences in the STEM learning community

Figure 2 also shows how the 7 different organisations participating in the STEAM4U project relate with different families of strategies. These organisations used the project framework to reflect on, rethink and re-design their initiatives in light of promoting a positive stance of STEM and raising self-efficacy. In this sense, they used a myriad of strategies and instruments to measure their possible impact, and focused in a particular family of strategies for research purposes. In the next chapters, the concrete experiences of these organisations during their 2 years of work within the project can be found. In the following paragraphs each of these families of strategies and how STEAM4U participants have made used of the strategy in their initiatives will be briefly presented.

Facilitate the self-regulation of students before, during and after the STEM activity

Actions included in this type of strategy are aimed at:

- Providing guidance to students to help them to be aware of their progresses throughout the activity (e.g. help them to know where they are in relation to the learning objective of the activity).
- Assisting students to develop more efficient strategies to carry out a task (e.g. help them to make a problem resolution scheme).
- Promoting students' emotional education (e.g. help them overcome anxiety before an exam)
- Persuading students about their own capacities before start and throughout an activity.

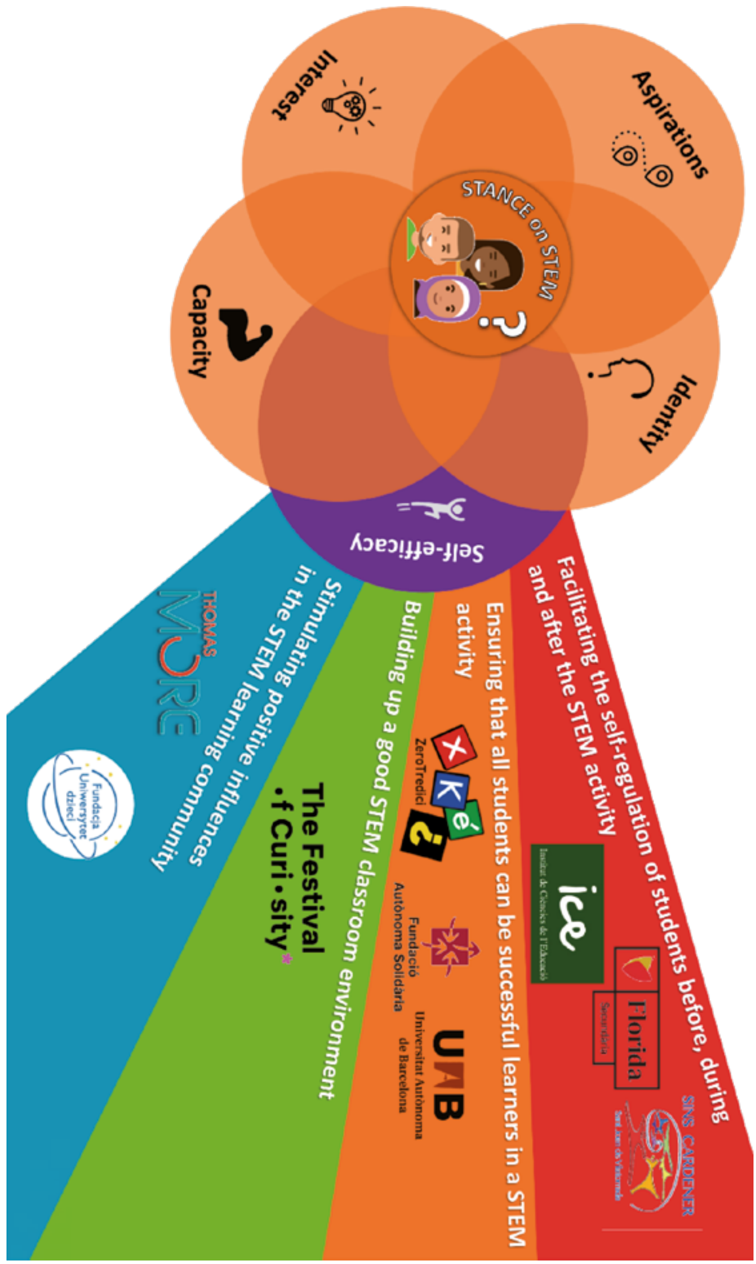

Figure 2. Representation of the 4 main type of strategies to raise self-efficacy in STEM carried out within the STEAM4U project by the organisations implementing them in their initiatives.

The secondary schools Florida Secundària and SINS Cardener, as representatives in the STEAM4U project of the network of innovative schools[1] of the ICE (Institute of Educational Sciences) of the Autonomous University of Barcelona (UAB), have been carrying out actions mainly addressed to these types of strategies. In particular, these schools have included different actions to promote the self-regulation of students in the implementation of a STEM school project.

Ensuring that all students can be successful learners in a STEM activity

Actions included in this type of strategy are aimed at:

- Classifying and sequencing the learning objectives and/or the key ideas of the activity in increasing order of difficulty, establishing an initial level suitable for all students
- Customizing the activity at the various learning rhythms (e.g., propose different ways in which the same activity can be carried out)

In the STEAM4U project, Xké? has been carrying out actions mainly addressed to these types of strategies by providing resources to teachers to carry out engaging activities in formal school contexts. The Solidarity Autonomous Foundation (FAS) of the Autonomous University of Barcelona (UAB), together with the Research Centre for Science and Mathematics Education (CRECIM), have developed a model of workshop for volunteers in an out-of-school project working with 12-14-year-old students with less opportunities.

Building up a good STEM classroom environment

Actions included in this type of strategy are aimed at:

- Change and challenge the roles of students in the classroom promoting positive exchanges between peers (e.g. review how roles are shared in a project to break negative associations between students and roles)
- Carry out cooperative activities instead of competitive activities to promote peer learning and reduce the activity stress

1 The network of innovative schools are formed by educational centres (primary and secondary schools) which would like or are implementing global projects taking care to all students. Schools participating in this network have integrated innovative aspects at the organisational and curricular levels and regarding the use of ICT and cooperative learning platforms.

- Review your verbal and non-verbal judgments to emphasize positive messages (e.g., promote optimism)

In the STEAM4U project, The Festival of Curiosity has been carrying out actions mainly addressed to these types of strategies. This organization has specially trained their volunteers to revise the key messages they deliver to participant families and kids, making an explicit effort to foster positive and empowering messages.

Stimulating positive influences in the STEM learning community

Actions included in this type of strategy are aimed at:

- Engage students in positive exchanges/experiences with STEM professionals
- Involve families in STE(A)M activities so that their children can show their successes to the family and feel they are valued positively
- Develop confidence of teachers in their own capacities to influence students

In the STEAM4U project, Fundacja Uniwersytet Dzieci and Thomas More have been carrying out actions mainly addressed to these type of strategies. These actions have promoted positive, informed and supported exchanges with adequately trained STEM professionals and between members of the family, respectively.

TO KNOW MORE

You can find more information on the STEAM4U framework to raise self-efficacy in STEM, the concept of stance on STEM, instruments to measure impact on this stance and the participating institutions of the STEAM4U project in the web: www.steam4u.eu

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"Scientific research" a project for learning how science works at 3rd year of secondary school

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KEY FINDINGS

- **Interdisciplinary projects 3rd year of secondary school.**
- **Learning the scientífic method in a personal research project.**
- **Sequencing questions (from lowest to highest) to a correct student learning process.**

LOW MOTIVATION AND BELIEVE IN THEIR OWN SKILLS OF SECONDARY SCHOOL STUDENTS FOR SCIENTIFIC VOCATIONS

Institut Cardener is a state -run middle school placed in a town with a population over 10.000 inhabitants.

In our school we follow approaches that are constantly searching to assist the learning student-centred learning in order to develop individual competences and abilities. In that way we began to work in 5 fields (communicative, foreign languages, physical education, artistic-musical and STEAM) so we are able to assess the evolution of each student from different points of view and in a more objective and holistic way.

SINS CARDENER

- The SINS Cardener started its activities in September 2012. We emphasize curriculum development through projects and learning from the perspective of socioconstructivists and systemic pedagogy. Our curriculum highlights a competence vision that favours the work of languages together with all STEM subjects.
- This promotes work in real environments and encourages classroom work outside the classroom in various situations. Thus, to do so, the center is opened to projects and collaborations with companies and organizations in the environment.

Within this change, the school is organized in 4 time zones of 90 minutes which are divided in “**plans d’acció**” (action plans), which are subjects from the different fields; **projects**, in which the students work in small groups by means of cooperative work; **tutoring sessions**, where teachers guide and do the monitoring of each student; and **workshops**, in which they can experiment in different ways.

Generally, when students progress in their studies and, in particular, in their transition to secondary education, they progressively lose interest for scientific subjects. One probable cause of this detachment is how teachers conceive the assessment in school, as a tool to quantify students’ performance. As a consequence, a large part of students discard scientific vocations for their future pushed by the idea that they can’t do it. This fact is easily observed in the low students’ percentage that choose these optional subjects in fourth secondary course and the number is even lower for the post-compulsory studies.

SCIENTIFIC’S TALKS, ACTIVITY SEQUENCING AND QUESTIONS TO IMPROVE SECONDARY SCHOOL STUDENTS’ SELF-EFFICACY IN STEM

In order to improve students’ own perception of their skills in STEAM, we re-designed our school project “the scientific research”, which was addressed to 3rd course of secondary education. The main aim of the re-designed project was to offer students an educational scenario in which they could have a first-hand and empowering experience of how science works, by designing and conducting a scientific research related their own personal interests. To this purpose, 3 main actions of improvement were undertaken: firstly, a redesign of the questions of the research project; secondly, an arrangement of the activities in increasing order of their level of difficulty (starting from the ones having the lowest level of difficulty level, towards the highest level of difficulty), so no students were lost at the beginning of the project; and finally, setting up scientific’ talks with professional of the STEAM field, so students could have a more personal approach of what people working on STEAM do. In each step, teachers provide positive support to empower students.

The final design of the project was structured into two parts: Once we introduce the project, in the first part students begin to work in small groups to learn all necessary knowledge related with the following parts; in the second part, students learn to work individually in the research of their personal investigation. The development of the project is shown in the Table 1 and it is described in the following sections.

First Part: Group Work	Project's Introduction	Starting activities: • Talks • Mystery boxes	Research questions		
Second Part individually research				Individually research: • Hypothesis • Experimentation • Results' analysis • Conclusions	Oral presentation of the results

Table 1. Representation of the project development

First part: cooperative work

The most important part of the project, in which we need to influence directly, is group work, because it is where our students learn how science progresses and what the scientific method is. For that reason two of the actions introduced (talks and sequencing activities) are in this part.

One of the first activities done in class is called “mystery boxes” (from science museum learning) in which students should deduce what is inside 6 closed boxes without opening them, only by using the tools that are at their disposal, just like scientists do. In groups, they have to reach an agreement in order to give an answer.

In second place, we carry out talks where the professional researchers answer students' questions.

Then, in groups of 5 students, they solve the starter questions in which they are supposed to learn what the scientific method is, and its specific vocabulary (hypothesis, experimental design, variables, result analysis and conclusions).

Second part: individually scientific research

Afterwards, and always with the teacher's guide and support, each student chose one research topic related with one phenomenon of his/her interest. The process of selection is open to students' preferences, so many different research topics can be found, such as: how mass affects to free fall, the liars' expressions, the influence of playing at home in sports, the candle size in an experiment of water absorption. After starting a bibliographic research, students design an experiment to confirm or reject the planned hypothesis. In the next photos are shown some of their experiments.

Figure 3. Images of some of the experiments undertaken in the Scientific Conference project carried out in the SINS Cardener

The last step of their scientific research is doing the results' analysis that are obtained in their experiment to confirm or reject their beginning hypothesis.

Results' presentations

To show the conclusions of their results, our students must record a video with their experimentation and one poster where they collect the different steps of their marked research by the scientific method: starting hypothesis, designing an experiment, making it and analysing results.

ASSESSING THE IMPACT OF THE ACTION PLAN (SCIENTIFIC'S TALKS, ACTIVITY SEQUENCING AND QUESTIONS, POSITIVE SUPPORT) IN SECONDARY SCHOOL STUDENTS AND TEACHERS

Methods and data collected were based on the work of Oñate, G. (2018). Both teachers and students were interviewed before and after their project participation. The question protocol was based on a review of theoretical conceptions about STEAM education, from a gender's perspective. For each item, a series questions were selected to be able to test the impact of the project on students' self-efficacy. Some of this group of questions were: how they feel, their own skills, teachers' strategies and other personal datum. In addition, personal students' interviews were undertaken to confirm the datum obtained through the questionnaire and allowed the students to express themselves with no time limit.

The data analysis procedures were based on the averages of teachers and students By analysing students' answers of the questionnaire, we made a statistical analysis of the average answers, both before and after the project, and were supported by the data gathered in the interviews. In first place, we did a datum extraction from questionnaires before and after the project in order to see the changes and awareness caused by taking part of this project. To observe if it followed a normal distribution, we used an excel complement called XLSTAT Saphiro- Wilk. Once we studied the datum, we went on evaluating the obtained results as it is shown in the following graphic.

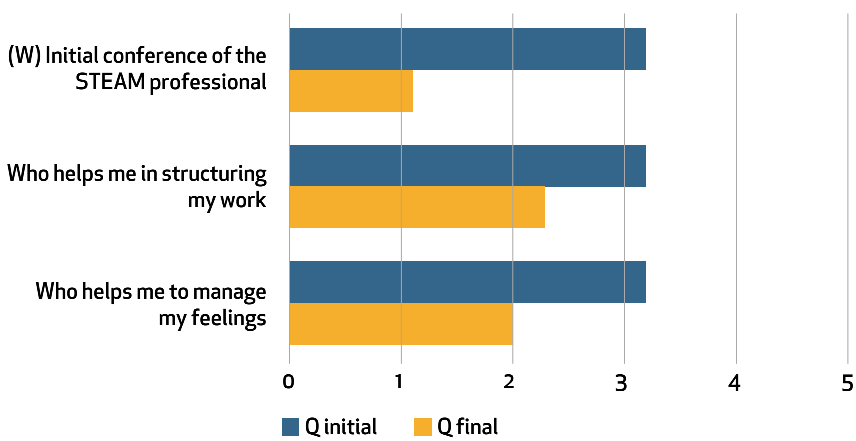

Figure 4. Results of the differences in the perceived usefulness of the learning strategies by girls. Answers to the question: Rate the influence of the following to make you feel you are able to do science; where 0 is *it does not help me at all*, 1 is *it helps me very little*, 2 is *it slightly helps me*, 3 is *it helps me moderatelly*, 4 is *it very me considerably* and 5 *it very helps me*

As we can observe in this graphic, girls' results in some questions are worse at the end. Unfortunately, we can't observe any other significant effect neither for boys nor for girls. The fact of participating in this European Project gave an opportunity to teachers to be more conscious of their influence in a lesson. Besides, using the scientific paradigm to find answers on personal students' interests is vital to dismantle the idea of science and elitism to empower students. However, we need to continue working in this sense for reconsidering class activities and make it understandable and motivational for our students.

CONCLUSIONS

In general terms, the participation of students in the scientific project helped them to reflect on their own skills, and be more aware about their efforts to achieve the objectives. "Try it, don't be scared, if I try I can research and learn by myself" is one of their comments in the interviews.

It is necessary to emphasize that girls valued some of the improvements introduced as experts' talks and teachers' support in a negative way. It may be due to their high expectations at the beginning of the project and that they might have thought they could have needed more teachers' help.

On the other hand, we did not observe any evidence in the boys' statistical results.

KEY MESSAGES FOR EDUCATORS

- **To promote feedback actions with students**
- **To make activitiy goals clear and sequenced**
- **To promote tutoring among peers**

FUTURE STEPS

There are mainly two important considerations for the next project editions that we should bear in mind: to provide a powerful scaffolding for the STEAM activities for students who can achieve the objectives, and in this way, to make the project less open; to fragment and make concrete goals to make them more accessible.

The second aspect that we should bear in mind is trying to vary the activities and questions in order to improve students' self-efficacy by genre, since boys and girls think they are able to do some actions more than others. So, if we want to improve both of them, we should provide differentiated activities.

TO KNOW MORE

Oñate, G. (2018). Anàlisi de l'impacte d'una activitat d'indagació i comunicació científica en el posicionament STEAM des d'una perspectiva de gènere; 2018.

"A scientific congress to improve the science self-efficacy of Secondary School students"

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KEY FINDINGS

- **Scientific Education on Secondary school: a different approach focused on the process that science follows to create new knowledge**
- **Interdisciplinary project working together experimental science (Physics, Chemistry and Biology) and Music.**
- **This is a specific version of a STEAM project created and implemented by secondary school teachers with 3rd ESO (9th Grade) students.**
- **Example of application of strategies to improve self-efficacy and its results.**
- **Empirical results obtained in the improvement of self-efficacy.**

LEARNING THE PROCESS OF RESEARCH IN SCIENCE THROUGH A STEAM CHALLENGE ON 3RD ESO

The Scientific Congress project from Florida Secundària is the result of a fundamental strategy (Arandía, 2004) of collaboration teamwork of 4 teachers from different disciplines with the idea of improving the interest and involvement of their students to learn in a deeper way Physics and Chemistry, Biology and Music curriculum together, as a specific way to respond the growing disinterest of students towards scientific studies (Solbes & Vilches, 1999).

Getting the 3rd ESO students to develop a real scientific Conference to internalize the process followed by science to generate knowledge has been the main goal of this interdisciplinary project. The success factors of this project have been based on students' curiosity, as a strategy of intrinsic motivation, on teamwork as an element of social learning, and on external collaboration to give meaning to the whole process.

The project has been developed on the academic courses 15/16, 16/17 and in the 17/18 course with new improvements resulting from STEAM4U E+ project.

FLORIDA SECUNDÀRIA: A COOPERATIVE HIGH SCHOOL

- Florida educational group is a Valencian worker co-operative created in 1977 working in the field of education. From its origins, Florida has worked in order to provide a high quality, participative and innovative education project, in close contact with companies and the society. The education and training provided to youngsters and professionals are based on the acquisition of skills and knowledge enabling them to successfully participate in the new business, professional and social scenes of current society.
- Florida is used to apply innovative methodologies to promote the socioeconomic development of the territories by generating inter cooperation experiences. Most of these methodologies are a result of a wide trajectory of participation on cooperation and research projects at regional, national and international levels.

A scientific congress also with music research?

The team of project teachers had detected the need to ensure that students could write an intellectual work where they really delve into the investigation of a specific topic. This work started from their own interest - choosing between thematic proposals marked by the team of teachers-, with the aim of avoiding superficial theoretical productions and with the intention of improving their capacity for synthesis. Knowing that the students have a big amount of information sources at their disposal and therefore it is relevant that they can learn to discern, to organize and synthesize it with their own criteria (Ten Dam, & Volman, 2004).

This situation generated the creation of a 4 hour weekly project module including the contents and learning standards of the 3 subjects mentioned above. This project module had a semester complement of 2h per week for Physics and Chemistry from September to February and 2h of Biology from February to June.

To establish links between the work done in the Secondary school and at University in order to cultivate scientific vocations and guide future studies to our students, one of the objectives set was also to design a project that could establish a bridge between both realities (Union européenne Commission européenne, 2007).

"The Scientific Congress" takes place during a two months period of the year. It comes out from the shared reflection of the team of teachers in which they agree the main framework of the learning objectives for 3rd ESO: put into practice the real process that science follows to generate knowledge. This agreement follows the idea that the reproduction of the scientific process by the students is an important base for the construction of the models that constitute scientific knowledge (Domenech-Casals, 2017, Caamaño, 2012; Llewellyn, 2005). From the epistemology of science it is a priority that students get to know this process starting with the steps of the scientific method and moreover, achieve the improvement of the rigor in their researches due to the fact that they are going to be evaluated by external experts. Another big priority of the project was to place Music in the same level of 'importance' that science to promote the relevance of this subject on the secondary students. The inclusion of Music as representative of the arts is a way to invite those students who do not feel comfortable in these disciplines and at the same time, a way to carry out a strategy to improve their self-efficacy (Zimmerman and Campillo, 2003). This is one of the reasons why it was decided to open the possibility of researches related to music in the frame of the Scientific Congress.

Likewise, artistic subjects have been losing prestige in recent years, passing to a second stage of importance for students and for general public as well. A proof of this situation is the change of compulsory to optional subjects in the Spanish regulation L.O.M.C.E. Arts subjects have become optional in many levels, so the inclusion of Music into this project also aims to integrate this subject, as a representative of arts, at the same level as sciences and thus shows the need for rigor and method in its development.

Apart from that, including music in this project tries to be an 'open door' for those students feeling low self-efficacy on science. The homogeneous types of students interested in science disciplines need to be amplified giving opportunities to others to feel capable into these areas. The presence of music on the project works as an attraction for their interest.

Curiosity is an internal human engine that helps to generate intrinsic motivation on students (Satiro, 2009) as an opposite approach to the repetitive, mechanical and memory tasks. Providing learning strategies that start from it –curiosity- is a key element that can push the work of students in this area in order to deepen the scientific literacy necessary for the citizens of 21st century (Vázquez & Manassero, 2008).

PROJECT STRUCTURE INCLUDING FORMATIVE EVALUATION STRATEGIES

The methodology and the different steps defined into the project were based on the purpose of teaching science developing creativity, problem solving, communication and metacognition in an integrated manner and not as differentiated actions in other spaces, as proposed by Pellegrino, Hilton and Learning (2012) and also with the objective of using evaluation as a learning strategy to ensure that students became able to regulate their own research process (Sanmartí, 2007). This principle supposed that the structure of the project has to ensure that students know:

1. Where they are, within the whole process: which is the point and moment of the project where the student are working
2. What they have learned: From the beginning of the project until the point where they are.
3. What remains to be learned: until the end of the project.

This objective requires preparing a flexible planning of the stages of the project to ensure that mechanisms have been established to generate metacognition in students (Campanario, 2009). It also implies that situations in which the teacher provides feedback to students must be established in order to ensure that they are aware of their mistakes. This structure generates improvements (Sanmarti, & Simón, 2006). This also means that every important aspect is evaluated during the work process and not only the final product.

The phases of the project must be structured taking into account the possibility of achieving these situations. Based on these criteria, the schedule was defined according to the sequence described below (every week takes 4 lessons):

PRESENTATION OF THE PROJECT *[1 LESSON]*
- Initial moment where teachers explain the challenge of this project.

UNIVERSITY SCIENTISTS CONFERENCE *[2 LESSONS]*
- Motivational talk where University professors explain what it is a Scientific Congress showing examples of conferences where they have participated.

RESEARCH QUESTION SELECTION *[1 LESSON]*
- The team of teachers prepares a catalogue of questions on which students can investigate.

TEAM WORK *[1 LESSON]*: Depending on the students' selection, teachers organize the work teams to start the research.
RESEARCH PHASE *[8 LESSONS]*: The students inquire about the previous ideas to be able to decide the aspects that will be investigated on the chosen topic that will serve as the beginning for the realization of the subsequent investigation.
PREPARATION OF THE THEMATIC RESEARCH WORK (TIT*) *[8 LESSONS]* • The instructions on the contents and sections of the so-called TIT are given by teachers and the students start to elaborate the first draft. • The first draft is presented to the thematic mentor (one of the teachers of the teachers' team). • The project teacher evaluates this draft and gives feed-back with the improvement proposals. • The students start making the final version of their TIT. • *TIT: from Catalan acronym "Treball d'Investigació Temàtic"
EXPERT PHASE *[8 LESSONS]*: Students develop different scientific products related to their research. The group assigns roles to their members so that each student assumes a responsibility within the group. • *Scientific article*: In the lessons of English subject students get help to write their Abstract.. • Scientific poster: In the lessons of Arts subject students get help to make their scientific poster. • Multimedia Presentation: The students get help from to prepare their Multimedia file that will serve as a support during the defence of their research on the ICT lessons.
DEFENSE OF THE RESEARCH *[4 LESSONS]* • The students prepare a preliminary script to ensure that all group members participate in the presentation?. • Oral defense in front of a tribunal of experts formed by University professors.
RESULTS *[2 LESSONS]*: The project teacher explains the results of each group and a qualitative and quantitative evaluation (on-line form) of the work is done by the students. The students also carry out a self-evaluation of teamwork and an evaluation of the phases of the project. .

Table 2. Structure of the project

Results of the Research

Throughout the 3 project editions carried out the most chosen subjects by the students have been:

Are there two formulas that explain the Universe?	Can I get the Zika virus?	Who were the Castrati musicians?
Is the sky blue?	How are sea turtles oriented?	How is music learned through the BAPNE method?
How can we know the age of the Tyrannosaurus Rex?	How do Sharks and Whales sleep?	Why do we tune the instruments to 440 Hz?
How can a spacecraft fly?	Can I be daltonic?	What is the mystery of the theatre of Epicurus?
How do emoticons travel?	Is the sweat of the hippos pink?	What is curiosity?

Table 3. Most selected research topics

Methodology

With the aim of collecting data to analyse the impact of the changes in the self-efficacy of the students who participated in the congress, a combination of quantitative and qualitative instruments were used. There were individual questionnaires before the project and after the project. There were also group interviews before and after the completion of the project. Methods and data collected have been based on the work of Oñate, G. (2018).

Improving students' self-efficacy strategies

The Scientific Congress was part of the STEAM4U E+ project and thanks to this participation it has incorporated various strategies to improve self-efficacy in students. These improvements focused on this objective were the following:

- To classify and sequence the learning objectives inside the steps of the project with an increasing difficulty, establishing an initial level accessible to all students.
- Use of different strategies to promote self-regulation to make them more aware of their own abilities, emphasizing their achievements.
- To involve students in exchanges with scientific professionals who show confidence and ability to adapt to failure.
- To prepare a list of topics at different levels to respond to the different learning curiosity and rhythms of the students.
- To promote collaborative activities instead of competitive activities through peer learning and decrease the tension inside the classroom.
- To pay special attention on verbal and non-verbal judgments to emphasize positive messages that recognizes the effort of students.
- To overcome the anxiety before the defence of the research they are prepared by doing rehearsal for this action.

RESULTS

After the introduction of the strategies mentioned above to improve the self-efficacy of the students, we found specific differences on important aspects of the project objectives when we compare the pre-test and post-test results.

Arguing in public the results of the own research, giving scientific explanations of different phenomena and obtaining conclusions from collected data have had some improvements after the process of the project and all these results together show a general improvement on the average of students' self-efficacy as we can see on the following figures.

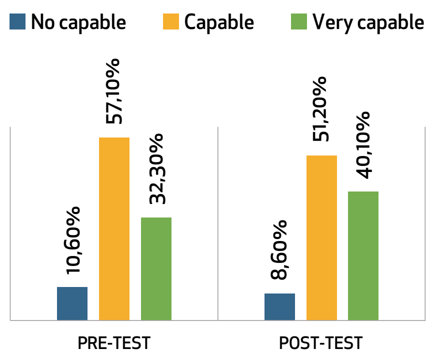

Figure 5. General improvement on self-efficacy

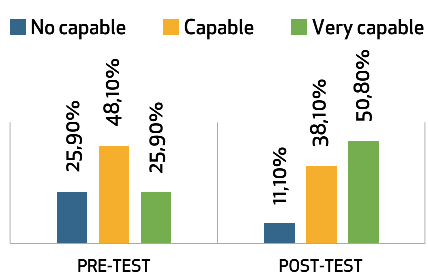

Figure 6. Self-efficacy to argue in public

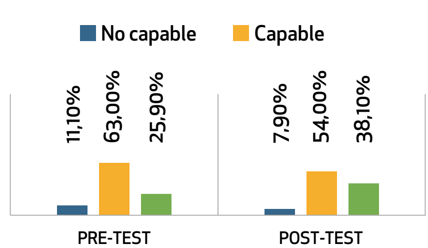

Figure 7. Self-efficacy to explain natural phenomena

CONCLUSIONS

The design of the didactic sequences is one of the most important teaching actions for the proper development of the pedagogical objectives of a discipline in the classroom. This process is usually carried out individually and without a pedagogical reflection process of quality due to the lack of time with which the teaching profession coexists. The possibility of designing a project in a cooperative way by a team of teachers coming from different disciplines is a motivational experience for participant teachers. Finding the time and the strategies to share proposals and elaborate them together supposes an extra cohesion to the defined project. Its execution in the classroom and the evaluation of the students' response provide a very positive feedback because it validates the design from practice.

Broadening this reflexive perspective by integrating it into a wider team, within the European project STEAM4U, has supposed a real improvement and it has allowed to provide broader pedagogical reflection to the learning process designed. An example of combined action and research that has made the project grow in the quality of its implementation inside the classroom.

When all this reflective contribution of teamwork is focused on a specific objective such as improving the self-efficacy of students in a scientific research, the results give a positive feedback to the work done. So far, with this practice, we have confirmed the importance of giving students the opportunity to choose their own research topic connecting it with their daily lives. Apart from this, the inclusion of Music within the Scientific Conference has provided more opportunities for success to more types of students and the opportunity to explain their own work to external professionals increases the importance of the student's achievement.

KEY MESSAGES FOR EDUCATORS

- **Give a link between everyday life of students and science it's a way to connect the students on the learning propose.**
- **Including Arts with science it's an open door inviting those students who feel low self-efficacy on science learning**
- **To invite external evaluators to give feed-back to the students research work it's a way to amplify the relevance of the students results**
- **Give the students the option to choose their own question to start their research it's a motivational factor that push them to stay connected on the whole process of research**

FUTURE STEPS

The project has easy transfer possibilities because its established structure allows any other school to incorporate it into its planning to be carried out in parallel, synchronously or asynchronously. This possibility would broaden the objectives of the project giving greater significance to the work carried out and would allow cross-evaluations between the students of the different schools.

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Playing with science

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KEY FINDINGS

- **Play as a medium can be effective in a group**
- **Cooperate and compete can walk together**
- **Teachers (and educators) are crucial in this process, but autonomy of kids is the real goal**

SELF-EFFICACY AFFECTS PERFORMANCE

Self-efficacy, better known as perceived self-efficacy by citing exactly the words used by Albert Bandura, corresponds to the awareness of being able to dominate specific activities, situations or aspects of one's psychological or social functioning. In other words, it is our perception of ourselves that we know that we are able to do, feel, express, be or become something.

From these beliefs come evaluations that lead to the development of goals or objectives. Therefore, the goals we wish to achieve derive from knowing exactly what we are able to do and by what means.

Research suggests that self-efficacy works as a hierarchical organization of beliefs with different levels of concreteness and complexity of the action to be performed; these beliefs profoundly

XKÈ? IL LABORATORIO DELLA CURIOSITA'

- Xkè? il Laboratorio della curiosità is a centre for schools (students' age 6 to 13) offering labs in science: teachers can choose among 27 different activities to have their classes live a hands-on experience in STEAM
- The main goal of the Centre is to approach science through creativity, curiosity and a playful experience.
- Open in 2011 for school classes (6 to 13) Xké? is a project focused especially on the idea of an innovative teaching method and to close the gap between kids and science.
- Organized in exhibits and based on the "hands on" method, kids are involved in group activities, games and positive competitions: they can learn by doing.
- Visiting Xké? is not like going to see an exhibition or a traditional museum. It requires interaction, it stimulates kids' curiosity with the overall goal of presenting them with a dynamic, unique learning experience.
  In 2018, over 1000 school groups @ Xkè?, 20.000 kids (6/13). 5000 children over the summer.

influence learning and also long-term development (Bandura, 2000a, Ehremberg, Cox and Koopman, 1991). The relationship between self-efficacy and performance is evident in the scholastic context, specifically in defining and organizing the student's learning methods and maintaining an adequate level of motivation in carrying out the proposed activities in the process of building up self-efficacy (Tsang, Hui and Law, 2012).

According to a study a few years ago, children with weakness experience have a low sense of self-efficacy about their academic and social skills, accordingly with previous literature (Bursuck, 1989; Grolnick & Ryan, 1990). Moreover, the study highlights that children with learning disorders even in primary school (or in any case in a state of fragility, not necessarily cognitive, but also social, economic, etc.) begin to develop a negative image of themselves (Ayres & Cooley, 1990; Clever, Bear, and Juvonen, 1992; La Greca & Stone, 1990). The low sense of self-efficacy and the negative self-evaluation contribute in the end to increase levels of social anxiety in children (Cowden, 2009). In this regard, it may be useful to structure educational activities on a cooperative basis and promote teaching practices, so that the most disadvantaged, improve and refine the mastery of the subject, their communication skills and their own self-efficacy.

Taking into account these theories, Xkè? and schools have developed together a specific hands on method on science, that reflects in this specific project. Xkè? had the chance to offer to 11 pilot classes – after the visit to the Centre – a play game with questions, activities and experiences whose aim was to raise the students' self-efficacy by playing together, acting in cooperative teams while competing. The questionnaire filled out by teachers at the end of the activities showed that the board game played in class was successful: students participated actively and as a consequence they were more involved into STEAM than before, raising their self- efficacy.

The artefact was able to set a new environment into that group, developing new skills and abilities. The key role of the teacher proved to be very important to make the experience possible and engaging, stimulating different competences in the educational framework. Xkè? is not a research centre, but a centre for applied activities.

For this reason, we believe we represent a very good trial test for new scientific findings that Universities or research centres can set on our stage. We noticed that this new set was also able to let the girls perform better than boys (see OECD about

Italy 2018 – Education at a Glance) and in Italy rural areas are more disadvantaged than cities. Moreover, a relevant component of educational poverty - the Italian Save the Children Report 2018 gives back an hard scenario - affects deeply performance. Is also noticed (even in EU science networks – Ecsite) that all informal education places can play important role in inclusion and gender issues.

STRATEGY: TEST KNOWLEDGE BY COOPERATING

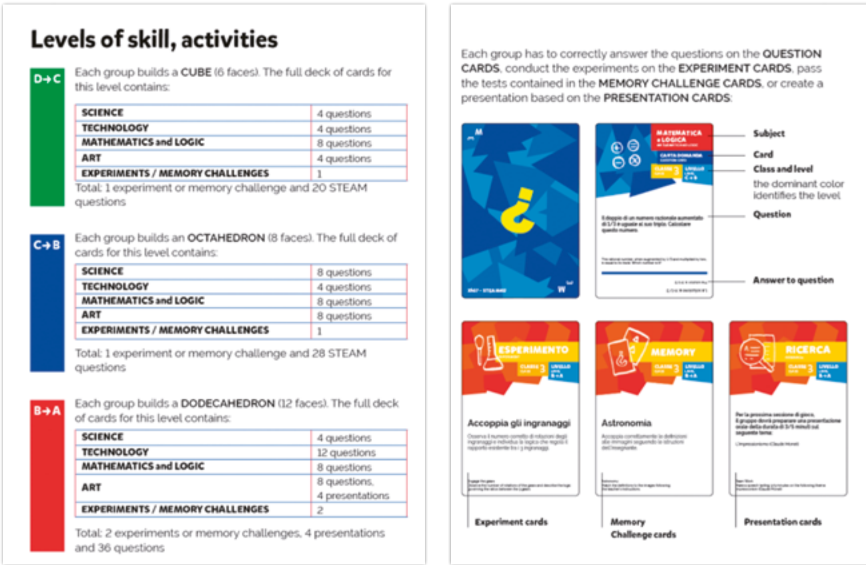
The main strategy was to design a tool to directly impact students' self-efficacy and a flowchart to indirectly impact students, through their educators (see following chapter).

The game tests the knowledge of students in various fields (art, technology, mathematics and science) while encouraging them to learn by working together. The class is divided into four groups which play the game simultaneously. All groups have to complete a level before they can move on to a higher, more difficult, level.

In each game session, each group has to reach its own milestones for the whole class to move to the next level of difficulty. This ensures a certain degree of cooperation between students from different groups. The objective of each group of players is to build a Platonic solid. On each solid, part of an enigma is displayed. The class has to solve the enigma together to move on to the next level of difficulty. To build its solid, each group has to win its parts (faces) by correctly answering questions on various subjects, successfully completing experiments, or passing memory tests. **Each group has to reach milestones to win faces**.

As the game proceeds, the teacher's role is to participate and encourage participation in a fun, informal yet content-rich experience. The groups take turns to ask and answer questions, with one group drawing a card (each card contains a question and answer) and another answering.

The teacher can intervene during the question-and-answer process to stimulate wider discussion on the subject addressed by the question (as playing time permits). The teacher also plays a special role in the experiments and memory challenges: each time an "Experiment" or "Memory Challenge" card is drawn, he/she reads out the instructions for conducting the experiment and using the necessary materials, then supervises the groups as they conduct their experiments.



Levels of skill, activities

D→C

Each group builds a **CUBE** (6 faces). The full deck of cards for this level contains:

SCIENCE	4 questions
TECHNOLOGY	4 questions
MATHEMATICS and LOGIC	8 questions
ART	4 questions
EXPERIMENTS / MEMORY CHALLENGES	1

Total: 1 experiment or memory challenge and 20 STEAM questions

C→B

Each group builds an **OCTAHEDRON** (8 faces). The full deck of cards for this level contains:

SCIENCE	8 questions
TECHNOLOGY	4 questions
MATHEMATICS and LOGIC	8 questions
ART	8 questions
EXPERIMENTS / MEMORY CHALLENGES	1

Total: 1 experiment or memory challenge and 28 STEAM questions

B→A

Each group builds a **DODECAHEDRON** (12 faces). The full deck of cards for this level contains:

SCIENCE	4 questions
TECHNOLOGY	12 questions
MATHEMATICS and LOGIC	8 questions
ART	8 questions, 4 presentations
EXPERIMENTS / MEMORY CHALLENGES	2

Total: 2 experiments or memory challenges, 4 presentations and 36 questions

Each group has to correctly answer the questions on the **QUESTION CARDS**, conduct the experiments on the **EXPERIMENT CARDS**, pass the tests contained in the **MEMORY CHALLENGE CARDS**, or create a presentation based on the **PRESENTATION CARDS**:

Figure 8. Distribution of the level of skills and activities in the game

From the Vademecum given to educators/teachers about the table play game content.

What's in the box

- **Instructions**
- **4 types of cards** (questions, experiment, memory challenge and research) arranged by skill level (D→C, C→B, B→A). Note: separate the cards by their level of difficulty and shuffle well before beginning the game.
- **materials for the experiments and memory challenges** (four sets of each, one for each group)
- **pack of bonus questions and score sheet**
- **faces**: these are assembled to make three [...] **colours**: 4 CUBES (level D→C), 4 OCTAHEDR[...] DODECAHEDRONS (level B→A). The colour [...] players, the type of solid identifies the level [...] been correctly assembled they show an en[...] must solve to move on to the next level of [...] solid is awarded for each experiment, prese[...] answered question).

How to play

STAGE 1

The teacher determines the starting level based [...] of the general level of the STEAM aptitudes of the [...] box the appropriate pack of cards.

The teacher then divides the class into four group[...] to each group. The teacher places the packs of Q[...] cards on the table, along with the experiment ma[...] sheet (the faces of the solids are distributed as re[...]

The game is played in sessions of 90 minutes. Th[...] long it takes the class to solve the final enigma.

STAGE 2

The **QUESTION** cards placed on the table contain [...] experiments, memory challenges and presentatio[...] must answer/complete to obtain the faces of the [...] the solids and solve the final enigma, allowing the[...] next level. All four groups must assemble their Platonic solids and work together to solve the final enigma so they can move to the next level.

The students are fully in charge of the game: the teacher's role is merely to coordinate and supervise (except during experiments and memory challenges).

WHO ASKS THE QUESTION	WHO ANSWERS
Green	Red
Red	Blue
Blue	Yellow
Yellow	Green

STAGE 3

The red group begins. The green group takes a card and asks the red group a question. If the latter answers correctly one point is entered on the score sheet. If it reaches a milestone, it is awarded a red face of its Platonic solid. If the group is unable to answer the question, it can draw a new card from the "Bonus" pack (to a maximum of 3 cards per game). Cards whose questions are not answered correctly are returned to the bottom of the pack. **If the group is still unable to answer the question, it wins no points and fails to reach a milestone**. If a card is drawn from a category for which the milestone has already been reached, the card is returned to the bottom of the pack. And a new card is drawn.

When an **EXPERIMENT** card is drawn, each group conducts the respective experiment to obtain the desired outcome; once it has completed the experiment correctly, it receives a face for its solid.

Similarly, when a **MEMORY CHALLENGE** card is drawn, each group does the challenge. If it completes the challenge correctly, it receives a face for its solid.

STAGE 4

Once the groups have received and assembled all the faces of their Platonic solids, they get together to sequence the final enigma and then report its solution to the teacher.

If it gives the correct solution, the class moves on to the next level of difficulty.

There is no "winning" group per se: to reach the final objective (i.e. move up a level) all groups must assemble their solids and work out the enigma which is distributed across the four solids. Once the class has reached the next level, play recommences until the class reaches level A.

Figure 9. Instructions given to educators

From the Vademecum given to educators/teachers: steps guide of the game phases

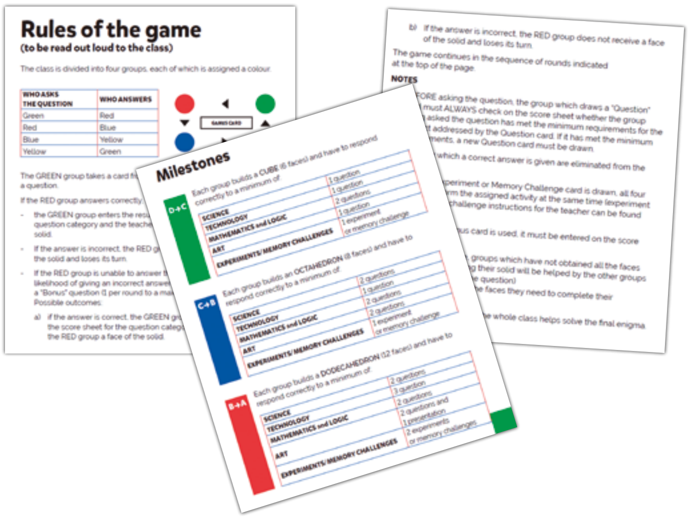


Figure 10. Rules of the game for children

XKÈ? LABS METHOD FLOWCHART

To stress the path between Xkè? and the schools, and to give a tool of how hands-on activities can be taken into class, we set up a flowchart.

- 4 moments for a path: the activity is divided in 4 moment (different length) to give rhythm and to have a framework.
- Question as tools to make the school group work together.
- Questions as tools to make the experience flow, to share, know content, discover that there are not wrong questions.
- Questions as a frame in which all "why?" are possible if they are organized and structured.

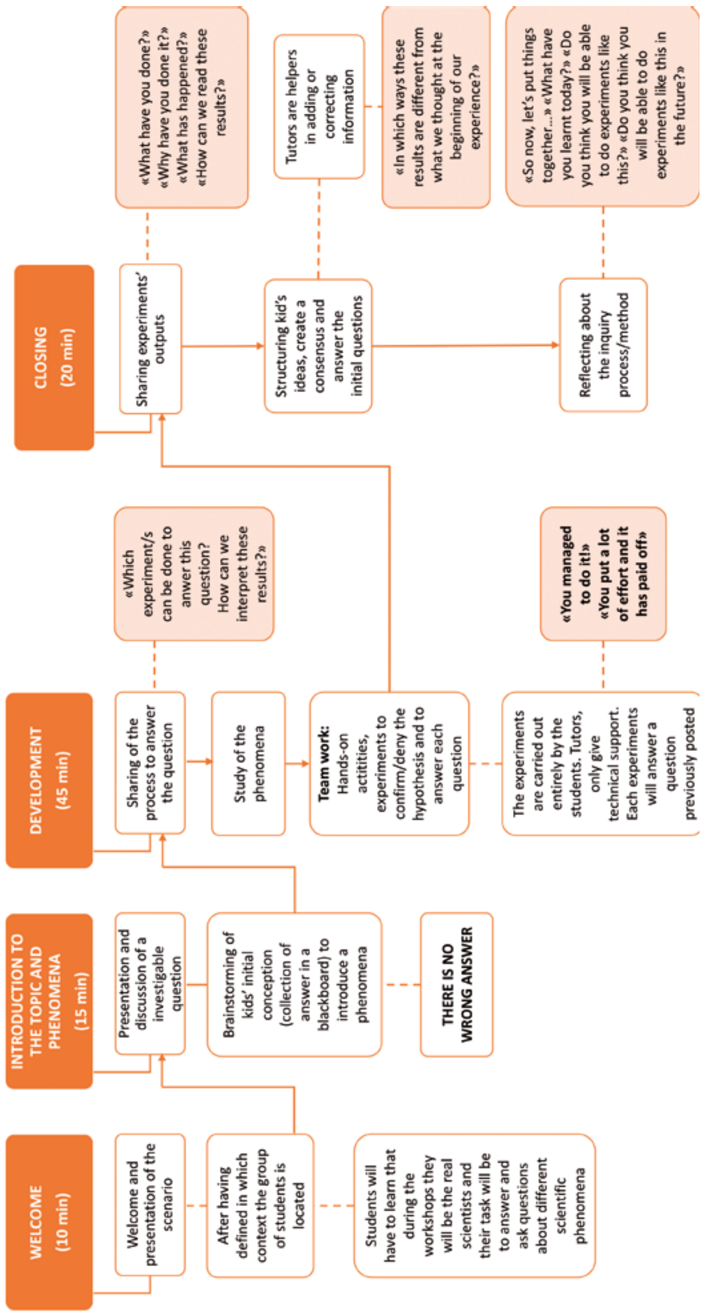


Figure 11. Flowchart of the Xké? hands-on activities

ASSESSING PARTICIPANTS' SELF-EFFICACY IN STEAM BEFORE AND AFTER LABS AT XKÈ?

Xkè? also provided a short questionnaire to the visiting students, before and after the activities, to measure if the experience was able to raise their feeling toward science and self-efficacy. The outputs were not able to give a significant feedback, maybe because the timeframe was too short or because of the distance between the labs and the idea of science. Despite the quite disappointing feedback, the students' questionnaire helped to better orient future activities to bridge the gap between science and young generations, by using tools and languages able to speed this process.

Different tools were used: initially a blackboard with stickers thumbs up and down (team work). In the process of gathering these data, was evident that the blackboard as a unique repositiy wasn't effective.

For this reason, a new tool was provided and data gathering with written questionnaires to be filled (individual work).

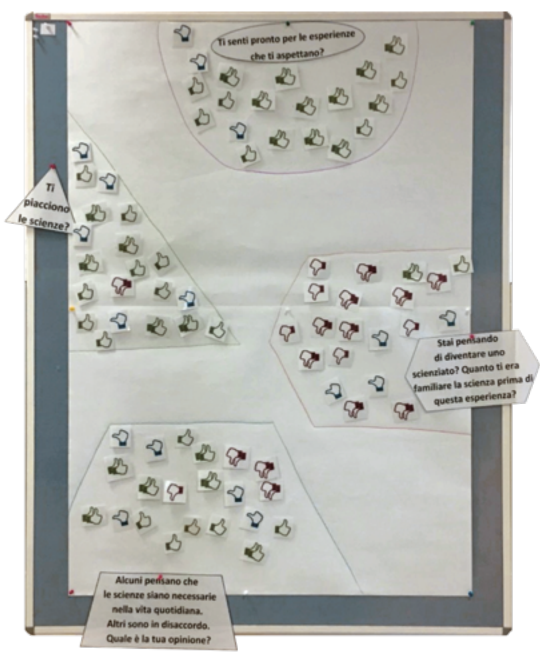


Figure 12. Representation of the data gathering at Xké?

27/03/2018
Institute
I.C. Orbassano I
Class: 2 A

BEFORE					
Are you able to do what are you going to do?					
How curious you are on science?					
How science is closer to you?					
Some thinks that science is necessary for their daily life. Do you agree?					
Are you considering to become a scientist?					

Legend:

YES A LOT
YES
SO and SO
NO
NOT AT ALL

27/03/2018
Institute
I.C. Orbassano I
Class: 2 A

AFTER					
Were you able to do what was expected?					
After this experience, how curious are you about science?					
Some thinks that science is necessary for their daily life. After this experience, do you agree?					
How science is after this experience closer to you?					
Are you considering to become a scientist?					

Legend:

YES A LOT
YES
SO and SO
NO
NOT AT ALL

Figure 13. Questionnaires for individual data gathering

Disappointing results

Xké? Underestimated the fact that an experience (even special) that lives in a short time frame cannot make a relevant difference in the questionnaire.

One shot experience was too challenging to give back a real feedback.

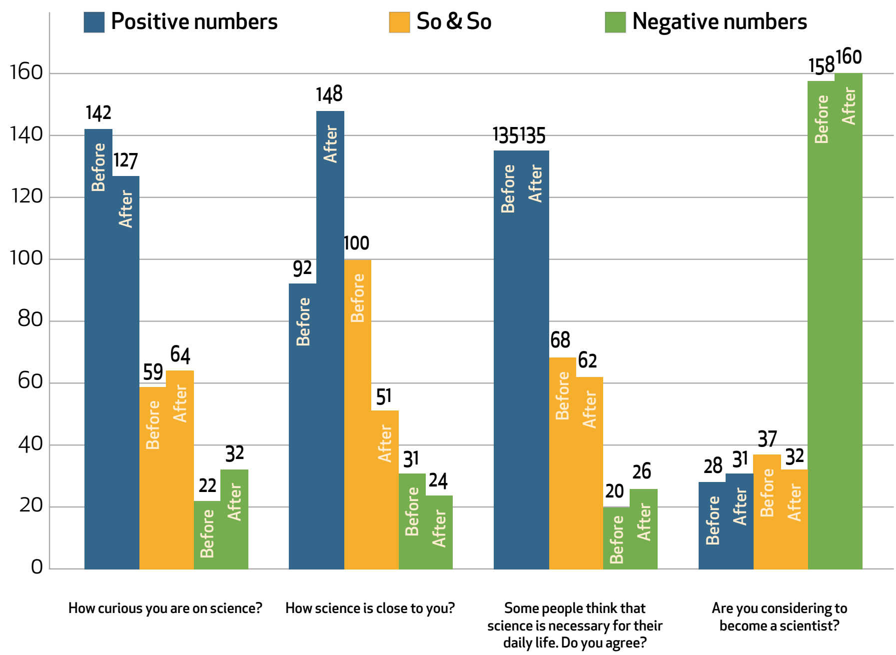


Figure 14. Results of the questionnaires at Xké? Addressed to children

ASSESSING THE OUTCOMES RELATED TO THE EXPERIMENTAL ACTION OF THE ARTEFACT ADDRESSED TO THE STUDENTS

The impact assessment was done by submitting a questionnaire to the teachers of the classes that participated into the trial process. Few questions referred to the experience of the table play game in the class. The closed-question questionnaire with a predefined scale of values was given to 22 teachers (2 for class).

The compilation by the teachers took place after the use of the board game in the classroom (made by Xkè? and donated to the participating classes). 3 or 4 play sessions during class time or after school have been practiced in order to test the artifact and verify its appreciation and effectiveness.

The results collected proved to be good (average 4.5) whose lexical rendering can be summarized as follows: The game proved to be very interesting. Some topics had already been dealt with in class, others not. This allowed a different approach to the new concepts and their deepening.

The activity allowed to approach the sciences in a playful and hands-on way, revealing a good tool to involve even the less enthusiastic students (often even the more disadvantaged, as literature recalls). "It was not always easy to deal with the questions proposed by the game, but this allowed to use different strategies such as the use of the interactive white board and other devices available at school".

The two main feedbacks from teachers were focused on efficacy of the tool and on the effect of the process on inclusion. The artifact has been a stimulus for students who have consolidated specific concepts and in-depth topics already covered. The natural competition between groups has raised the interest of the students was replaced by the need to cooperate to achieve a common result. The self-efficacy of the disadvantaged students has increased thanks to the use of ludic approach and hands on activities into the process of learning.

The questionnaires were submitted to 22 lower secondary school teachers.

Results of the survey given to teachers.

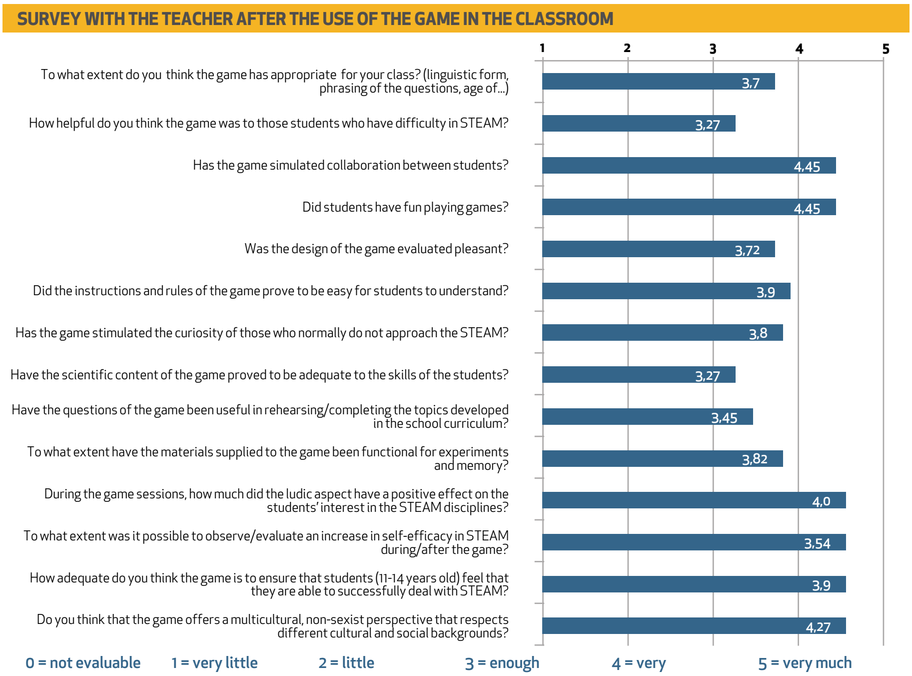


Figure 15. Results of the teachers' questionnaires (22 lower secondary school teachers)

A CHANCE TO GO DEEPER IN THE CONTENT

A senior tutor voice

Figure 16. Serena Berbotto feedback (Senior tutor in charge of after school activities)

"The activity has been also piloted in after school programs: the results were very good. The idea of playing with science was also the chance to review and sometimes disclosure new knowledge. The competition between teams was particularly strong from the very beginning, and this was crucial to keep their focus. The group was really mixed, by gender and by diversity (fragile and problems with attention disorder); the rule games were perfectly understood and respected.

Not all the topics of the game were part of the students' curricula (belonging mainly to tech and science schools), as institutes can set part of their program autonomously, within a general and national frame. The bonus cards were very helpful in overcoming these problems and in refreshing the group the on field activities taken at Xkè? The other parts of the game (memory card, small research and experiments) were very engaging and raised the ability of cooperate, "forcing" the students to help each other.

Some levels took longer (D to C and C to B levels, up to 5 hours), as they gave the opportunity to go deeper in other topics (especially math and science, making experiments and showing videos in class); this suggests that the activity can be divided in 2 part. The role of the tutor/teacher is crucial to follow the path of the game and to orient the activity into specific moment following the steps of the game.

The group gave some feedback: expand the practical activity; give more time to the part of public speaking (tell the group about your findings). Finally they admitted that their knowledge in science was greater than they expected: this is a way (through experiences) to raise self-efficacy".

CONCLUSIONS

Lesson learned:

- Use the right tool
- Time is needed
- The process more than the product

This project gave Xkè? the chance to set a new tool, using the hands-on approach that makes the Centre so special in Torino and also in a bigger (national and international) panorama. The lesson learned for Xkè? (to be shared primarily with partners) is that choosing the right tool is crucial to make a success out of the content. A second lesson learned very important is that autonomy is fundamental to raise self-efficacy.

The table play game reached the public in the right way and engage 11/13 year-old students form the very beginning. The process of cooperating and competing, the ability of raising self-efficacy is more important than the final product (the solid). *It is crucial that the teacher knows very well the structure and the organization of the play table game; they should* study the game's questions and answers in advance to be as supportive as possible, without stepping into the game.

Cooperation with the teacher is crucial for a good result, especially in guiding questions that may refer to general knowledge, for this reason it is very important that the teachers study for the game in advance. But the most important thing is to grant kids the autonomy to play, discover, make mistakes and improve. Every experience takes time: like bread dough needs time to rise, self-efficacy needs time to develop.

KEY MESSAGES FOR EDUCATORS

- **To raise self-efficacy, autonomy is fundamental**
- **A good tool/method can make the difference**
- **Teachers as supporters**

FUTURE STEPS

This project/experience gave us the chance to set up a new tool. The table play game proved to be a very effective platform to keep together a class group on different dynamics, where also the more fragile could be active part of the process, where competition is stepping back for cooperation, where equity issues (gender) can be addressed as girls play more active roles into the process.

In the future, this piloting can be scaled up in more diverse environments, after school programs, in order to give continuity to a different, more inclusive approach to stem and steam.

TO KNOW MORE

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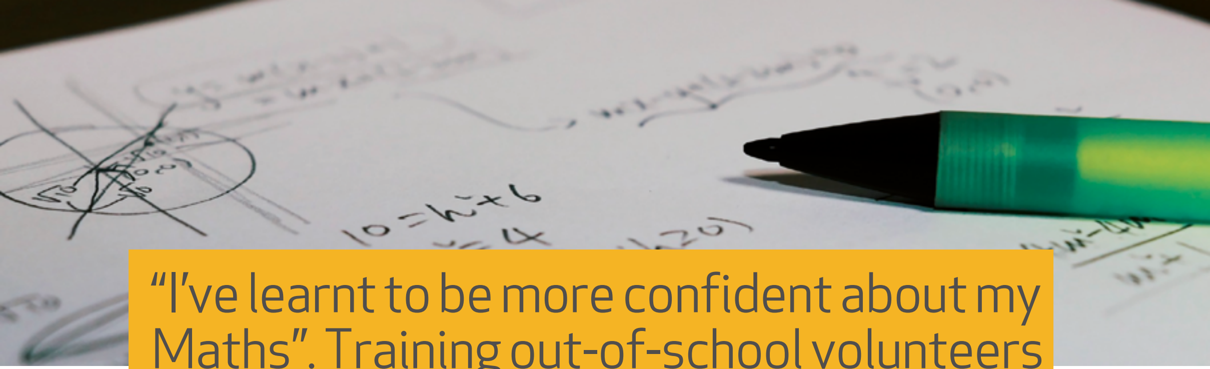

“I’ve learnt to be more confident about my Maths”. Training out-of-school volunteers to raise students’ self-efficacy in STEM

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KEY FINDINGS

- **Out of school activities allow engaging and playful educational methodologies while working with math contents in an innovative way. However, if the learnt content is not explicitly disclosed these activities have low impact in the self-efficacy in STEM at school**
- **Training methods based on real examples of similar educators, such as professional noticing, allow volunteers with different backgrounds to develop their teaching competences and Math self-efficacy.**
- **Initiatives addressed to raise out-of-school educators’ and students’ self-efficacy show positive but timid impacts. Non-surprisingly more actions in this line are needed to effectively change such deeply rooted believes.**

AN ENTRENCHED LOW SELF-EFFICACY IN MATHS OF SECONDARY STUDENTS FROM DEPRIVED SOCIAL BACKGROUNDS

The Universitat Autònoma de Barcelona (UAB) is a young public university situated in the outskirts of Barcelona, in a quite socio-economically deprived area. The context of this study is one of the social programmes of the UAB, the programme Unix (FAS), which involves university volunteers and 13-15 year old students from public schools in its surrounding. Students participating at the UniX program come from 4 different secondary schools. These students face diverse hardships at their homes, usually not having the necessary resources, environment and support to develop adequate study habits. These adversities result in low academic performance in class which is both cause and effect of a low sense of academic self-efficacy that schooling is not able to revert. As these students do not have the financial resources to participate in out-of-school support activities that help them to break this trend, low academic performance and low sense of self-efficacy are perpetuated and aggravate along time, even endangering these students' likelihood of finishing their compulsory studies.

Students of the UAB volunteer at the UniX to carry out Maths activities with the aim of providing opportunities to these students facing learning and familiar hardships. These volunteers have diverse backgrounds, some of them coming from STEM degrees (Science, Technology, Engineering, and Maths), and some of them coming from Social Sciences' degrees (Primary Education, Sociology, Psychology…). In addition, they also have different experience with out-of-school activities with teenagers. Personal past experiences of these volunteers as secondary school students are usually what motivates their participation in the UniX program, as expressed this student of Chemistry in an initial interview:

> When I was a teenager, I was not like the other girls in my class. I did not like the topics they liked nor the jokes they did, and this make me felt disengaged from school. My own experience as student may help me to understand how UniX students feel. I want to say them that they also have things to say and to do.

These initial feelings predispose UniX volunteers to empathize with the 13-15 years-old students they will support, and to act as a positive role models.

In the academic course 2016-2017 an evaluation of the impact of the UniX program was undertaken, revealing that, although secondary school students benefit from the participation in the program improving their performance in school, their self-efficacy beliefs in Maths remained unchanged. In a long-term perspective, an unchanged low self-efficacy in Maths usually results in detachment from STEM activities (Bandura, 1993). Thus, in order to ensure the future STEM literacy of these students and allow STEM aspirations in spite of the low scientific capital of their families (Archer & Dewitt, 2015), the UniX program should be revised. Within the framework of the STEAM4U project a new model of UniX workshop and subsequent training was carried out to increase the impact of the UniX program on students' self-efficacy beliefs in Maths.

SOLIDARITY AUTONOMOUS FOUNDATION AND THE UNIX PROGRAM

- *UniX is a program of the Solidarity Autonomous Foundation (FAS) of the Autonomous University of Barcelona (UAB). This program is aimed at promoting Math and transversal competencies of 13-15-year-old secondary students of a deprived area in the nearby of the university.*
- *The UniX program takes place after school hours and is carried out by more than 10 volunteer students from different university degrees of the UAB. A total of 4 secondary schools and 60 secondary students participated in the UniX program during the 2017-2018 academic year.*

INCREASING CONFIDENCE IN MATH'S ABILITY: THE TRAINING OF UNIX VOLUNTEERS

Development of a new model of the UniX workshops

The new model of UniX workshop was aimed at raising students' self-efficacy in Maths by providing an engaging educational context, a low entry-level (an easy barrier of access to the activity) and an adequate sequence of learning steps so that leaps of difficulty become affordable for students and equilibrated throughout all the activities.

The workshop was centred on the polyhedron identification, 2D-3D relationships, transformation within the plane and placement and location in space, as shown in (Figure 17). The model of workshop was designed to be carried out in 6 sessions (Figure 18).

Sessions S1 and S2 of the workshop were devoted to play in teams a Math game named Tridio©, as described by Ribosa & Durán (2017) (Figure 18).

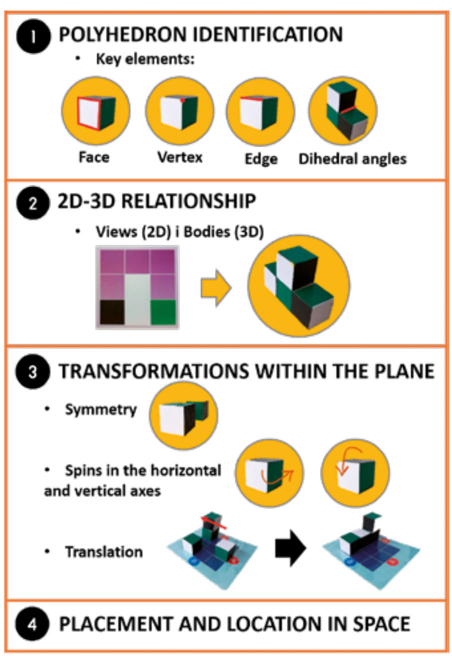


Figure 17. Representation of the Math content covered in the model of UniX

Figure 18. Summary of the development of the model of UniX workshop

S3 of the workshop was aimed at applying the knowledge built in the previous sessions to the deployment of diverse cubes in the plane and identifying mathematical patterns with construction pieces[2]. The S4 of the workshop was aimed at discussing different perspectives of a same figure, from different situations[3]. After the S1, S2 and S3 students were given complementary Maths challenges that they have to resolve at their homes[4]. These challenges were related to the content of the previous sessions. During the following session, de resolution of the challenge was discussed, with a special emphasis on the different strategies to achieve it. Finally, in sessions S5 and S6 of the workshop, students were asked to prepare a challenge for their colleagues, similarly to the challenges carried out previously. A 7th extra session was planned in which all students would present their work in a public event at the local theatre.

2 Complementary material can be accessed here: http://steam4u.eu/wp-content/uploads/2018/06/Microsoft-Word-ENGSessió-3Document.pdf

3 Complementary material can be accessed here: http://steam4u.eu/wp-content/uploads/2018/06/S4-From-2D-to-3D.pdf

4 https://www.dropbox.com/s/go2wcmiw3uigq0i/Challenge%20your%20Brain_V5.pdf?dl=0

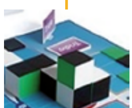
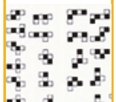
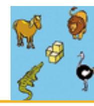
SESSION	S1	S2	S3	S4	S5	S6	FINAL SESSION
Activity	Present the workshop & play Tridio game 	Play Tridoi game & finish the game challenges	Promote students' thinking about Math content 	Contextual application 	Preparation of communica-tions 	Preparation of communica-tions	Public presentation at the theatre 
In-between sessions' challenges		Challenge 1	Challenge 2	Challenge 3			

Figure 19. A group of students playing Tridio® game and discussing about Math during the UniX workshop (1st session).

A volunteer first piloted the implementation of the workshop, which was carried out at the beginning of October 2017. Results, videos and data from this pilot workshop with students was used as a model for the training of volunteers. The final implementation in 4 schools was carried out by the volunteers from December 2017 to January 2018.

Training of UniX volunteers

The training of volunteers took place from September 2017 to January 2018. Initial data gathered from the volunteers revealed 2 different needs: volunteers from STEM degrees (STEM volunteers) were used to do Math in their university preparation and did not hesitate about their Math abilities. However, they felt insecure about their educational competences to manage groups, especially in the presence of disruptive situations or students, and in how to teach math to youngsters. On the other hand, volunteers from social science degrees (SS volunteers) were confident about their competences in managing groups, but expressed strong reluctances about their own Maths skills. This situation led us to set 2 different aims for the volunteer training: to raise volunteers' self-efficacy in Maths (especially for SS volunteers) and to raise volunteers' self-efficacy in Math teaching (especially for STEM volunteers).

The design of the training was based in the proposal of Sherin, Jacobs, & Philipp (2011) around the concept of *teachers' professional noticing,* which draws from the experience of the educators' themselves while, experiencing and observing an activity (in our case, the new UniX workshop of Figure 2) to build the desired teacher knowledge cooperatively. Thus, it combines focus groups' sessions of reflection and discussion with experience and implementation the activities. As it is also shown in Table 4, the volunteers’ training consisted on 3 focus-group sessions organised around 2 implementations of the new UniX workshop, the pilot and the definitive implementations.

Training session	S1: presentation and familiarisation with the STEAM4U workshop		S2: Analysis of episodes of the pilot implementation		S3: Analysis of own practices
Implementation of STEAM4U workshop		Implementation of the pilot STEAM4U workshop (1 volunteer)		Implementation of the STEAM4U workshop (other volunteers)	

Table 4. Structure of the training of the volunteers and the implementation of the new model of the UniX workshop.

The **first session** of the training (**S1**), was devoted to present the new model of UniX workshop to the volunteers. Volunteers were asked to play and participate in different Math activates to familiarise with the dynamics of the workshop as students themselves. Then, it was discussed what Math content was involved in each activity, which strategies each volunteer had used to solve challenges and which had been the most successful ones (Figure 20).

Figure 20. A group of students playing Tridio® game and discussing about Math during the UniX workshop (1st session)

After this first session, a volunteer accepted to implement the model of UniX workshop with their students (**pilot implementation**). A team of researchers observed and recorded this implementation, selecting some relevant episodes in which self-efficacy beliefs of students were manifested and/or opportunities for the construction of Math knowledge were identified.

In the **second session** of the training (**S2**), relevant episodes of this pilot implementation were analysed with the rest of volunteers in terms of the Math knowledge construction and the self-efficacy beliefs made explicit by students. Volunteers had to discuss those aspects by answering questions such as "what is the most relevant thing of the episode for you? How can you interpret what students say?". Special emphasis was placed on discussing the teaching strategies used to promote deep construction of the Math knowledge and to authentically raise self-efficacy. Volunteers also had to co-design alternative, more sophisticated strategies to better achieve these same aims.

Figure 21. Representation of the second session. Volunteers watched and discussed some relevant episodes of the pilot implementation.

After S2, all volunteers implemented the model of UniX workshop with their students. Since the implementation was simultaneously carried out in 4 secondary schools, all the implementations could not be observed and recorded by the research team. In order to gather appropriate data for the subsequent session, volunteers were asked to identify and describe the relevant episodes that happened during their implementation.

After this second implementation, a **third training session** (**S3**) was carried out. Similarly to the second session, relevant episodes brought by the volunteers were analysed and discussed with the rest of the volunteers. The design and complementary materials of the training can be accessed through the following link: https://goo.gl/H3r4DW

ASSESSING THE IMPACT OF THE VOLUNTEER TRAINING AND THE NEW UNIX WORKSHOP ON PARTICIPANTS’ SELF-EFFICACY

All volunteers and participant students were surveyed before and after their participation in the training and implementation of the new UniX workshop, respectively. Both questionnaires used were aimed at revealing volunteers and students’ self-efficacy in Maths among other related variables, and were based on previous questionnaires from the literature gathered in the STEAM4U toolkit[5]. In addition, a selection of volunteers and participant students were also interviewed using a semi-structured protocol before and after their participation.

Gathered data from the surveys was analysed quantitavely using statistical analysis. Data from the interviews was analysed qualitatively, using a bottom-up approach for the emergence of categories that compare, collapse, describe and interpret participants’ views.

“I DO NOT WANT MY STUDENTS TO GIVE UP”. RESULTS OF THE IMPACT OF STEAM4U TRAINING ON UNIX VOLUNTEERS

Data gathered from the questionnaires, interviews and observations provided information on the impact of the STEAM4U initiative on the participating volunteers. 8 university students that volunteer in the UniX programme received the STEAM4U training and participated in the implementation of the new UniX wor-

5 http://steam4u.eu/homepage/the-steam4u-toolkit/

kshop. 4 volunteers (3 boys and 1 girl) came from STEM degrees and 4 volunteers (4 girls) came from Social Science degrees. However, 2 volunteers (girls from Social Science degrees) gave up the program in the middle of the implementation of the workshop, making a total number of 6 volunteers participating in all the initiative (4 volunteers from STEM degrees and 2 from Social Science degrees).

At the end of the training and the implementation of the workshop, most of the volunteers acknowledged having developed their strategies to help students to learn Maths. The *professional noticing* training methodology was much appreciated by volunteers because it was based on real examples of the implementation of the workshop, and promoted meaningful discussions about Math teaching strategies and strategies to raise self-efficacy. Volunteers considered that this model of training provided concrete ideas about what they could do in class afterwards (which problems could they face? How could they overcome them? How to make the most of their intervention in terms of raising self-efficacy in Maths and promoting Math competences?).

However, volunteers also complained about the detailed design of the workshop, which left them little space for doing other things with the students. Volunteers reported that when students felt anxious because they had lots of homework or upcoming exams, they preferred volunteers' help with these school tasks than to *play* with the Maths games. Though volunteers tried to answer these occasional needs, the timing of the sessions of the new UniX workshop was tight, leaving little extra time for them to adapt to students' urgent needs.

> Students sometimes were anxious about having lots of Math homework or for the Math exam they were having the following day. In these situations, they did not want to play the game or participate in the workshop, but to study or to do homework with us. They felt that the game was not useful for what they were doing at school. Maybe, when we plan the UniX workshop (for the next implementation), we could have into account these periods in which students will be more stressed to help them better or try to connect what we are doing at UniX with what students are doing in their classes.

Hence, more flexibility in the implementation of the workshop was introduced in the revised design of the model of workshop.

Apart from these general evaluations, results of the impact of the training and the implementation on volunteers' self-efficacy revealed strong differences among volunteers based on their backgrounds: experience of those volunteers coming from STEM degrees (STEM volunteers) were significantly different than those volunteers coming from Social Science's degrees (SS volunteers). Such differences in the impact on volunteers' self-efficacy are explained below.

Raising self-efficacy in Maths

Initial interviews and questionnaires revealed that SS volunteers held low levels of self-efficacy in Maths, similarly to the students participating in the UniX program. In this sense, data gathered displayed a significant improvement in self-efficacy in Maths of those SS volunteers. However, this improvement was mostly specific to the Math content covered in the UniX model of workshop (e.g. 2D-3D relationship). When asked in general, these same SS volunteers still expressed reluctances about their competences in the area:

> The training was very useful to shift my own fears and to change the "I am no good for this" (...). Now I feel much more confident implementing a UniX workshop, but still I do not feel able to design my own Math workshops, because I do not have the proper Math knowledge to do it.

Conversely, STEM volunteers held high initial self-efficacy believes, and results of the survey and interviews proved no impact on this construct. In other words, at the end of the training and of the implementation of the model of workshop, all volunteers showed a great level of self-efficacy about the specific Math abilities involved in the proposal of workshop, but when asked in general, only STEM volunteers maintained a high level of self-efficacy in their abilities in the Math area.

These results confirmed that self-efficacy beliefs are strongly linked and narrowed to a particular task and at a particular level (Bandura, 2006). For instance, a volunteer can believe that he or she will be very capable of solving a particular Math challenge involved in the UniX workshop, but feel not able to solve another algebra problem. Self-efficacy in the Math area, though, is the result of a compilation of self-schemas that are created from earlier experiences and that would need abundant experiences of success to change it, as reported by Bong & Skaalvik (2003). Raising self-efficacy in the STEM area is a long-distance race. In this sense, volunteers' self-efficacy in Maths did not increase to a great extend along the training experience. Our viewpoint is that many more workshops like this one would be needed to have an impact in such a deep-rooted concept as self-efficacy in an area.

During the interviews, some elements of the training and the new workshop design were highlighted by the volunteers as boosters of self-efficacy. In particular, the first session of the training, devoted to carry out the UniX workshop as a student, was especially valued for those volunteers with lower levels of self-efficacy in Maths. SS volunteers valued that the proposed activities had a low entry level, that is, that the activities were accessible to everyone whatever their math competence. Another element valued by volunteers was the trainer conducting the training, who was described as charismatic. They explicitly mentioned the key messages she gave them and how they helped to break their initial reluctances, engaging them in the activity and helping them to persist despite the difficulties. These two elements have been also reported in the work of Zimmerman & Campillo (2003) as successful strategies to promote self-efficacy, and reassured us about the positive impact of the training on volunteers' beliefs.

Apart from these two strategies, volunteers highly appreciated the teaching materials of the new workshop, aimed at helping them to implement this same workshop in their UniX session afterwards. Specifically, volunteers valued the detailed instructions and recommendations for all activities, as well as the samples of possible both right and wrong answers for all the activities and challenges.

> The Tridio® game went very well. The challenges motivated the students and engaged them in the sessions. And for me, having the solutions to the challenges, made me feel much more confident when doing the activity.

As it can be extracted from the interviews, these materials helped the volunteers to gain confidence during the preparation of the workshop. During the implementation they also acted as aids and backups if they felt they were losing track of the activity.

In addition, the volunteer in charge of the pilot implementation of the workshop valued very much the presence of an expert in the field while she was implementing it. This expert was a researcher carrying out observations and was only aimed at collecting data. However, at some points when the volunteer felt insecure with the Math content, she came out to help the volunteer, giving rise to some informal episodes of co-teaching. Unfortunately, we did not have the resources to provide an expert to the rest of volunteers while they were implementing the new workshops for the first time, but we believe that this non-planned and occasional co-teaching holds promising prospects of raising educators' self-efficacy on the content, similarly to its already reported benefits in the professional development field by Pancsofar & Petroff (2013)and other authors.

Raising self-efficacy in Math teaching

Impact on self-efficacy in Math teaching on both STEM and SS volunteers was also different. Volunteers coming from STEM degrees initially felt fairly confident about their Math knowledge and, although they acknowledged little or no experience in Maths teaching, they were also confident in their abilities to teach Maths. Thus, were mostly interested in developing their skills to managing groups with possible disruptive students:

> I am studying a degree in Chemistry, so my Math knowledge is good. However, I felt uneasy with the group managing, especially when thinking what I could do with the more disruptive students.

As the training progressed, those volunteers started to realise from the examples and the questions posed by the trainer that teaching Maths was something more than having a good Math knowledge and/or skills to manage groups, but to know how to ask good questions in class and at the right moment to stimulate students' Math reasoning, identify which cognitive difficulties students were facing, another elements included in what Shulman (1986) defined by Pedagogical Content Knowledge (PCK).

Although it was positive that the training made the volunteers aware of the competences needed to teach Maths, data gathered proved that more training would have been needed to develop a good teaching level of pedagogical content knowledge on the volunteers. At the evaluation of the last training, STEM volunteers acknowledged facing difficulties in the UniX workshops to identify when and how to pose good questions to students either to promote their Maths competencies or to raise their self-efficacy in Maths. STEM volunteers also recognized that was much easier for them to reproduce traditional teaching practices (lectures, etc.) than carrying out a lesson based on social construction of mathematical ideas, despite that learning through dialogue engaged their students much more. Hence, data gathered at the end reflected this raise of the awareness of STEM volunteers of Math teaching competences, but almost no impact on their self-efficacy in Maths teaching. A bigger impact for those volunteers should be expected of longer training programs.

Impact on self-efficacy in Math teaching of SS volunteers was slightly different. As described before, these volunteers had low sense of Math self-efficacy and expressed serious doubts about their abilities to teach Maths, as this volunteer expressed:

> I have not ever been a good Math student, so I am not sure if I will be able to do it well (the implementation of the workshop).

However, these volunteers felt confident about their general pedagogical skills (knowing of broad principles and strategies of classroom management and organisation, knowing of different educational contexts, educational purposes, etc.).

During the training, we observed that their increase of self-efficacy in Math teaching was fast as soon as these volunteers felt confident about the Maths topics involved in the workshop. In other words, knowledge of the content acted as a limiting factor for these volunteers. Thus, and conversely to their STEM colleagues, volunteers coming from social science degrees took much more advantage of the reflections centred in the Maths contents involved in the UniX model of workshop, rather than of the discussions about the teaching skills throughout the training.

It is important to note that the raise of self-efficacy in Maths teaching of those SS volunteers was narrowed to the particular Math content, similarly to their self-efficacy in Maths reported previously. Thus, when asked at the end of the STEAM4U challenge if they would feel capable of doing and designing new UniX workshops, they still expressed strong doubts about their competences. In the interviews, these hesitations showed to be motivated by their low sense of self-efficacy in the Math area. These findings reinforce the role of Maths' knowledge and Maths' self-efficacy as limiting factors in the professional development of these profile of volunteers, and has been extensively reported in the literature since the work of Shulman (1986).

In practice, we observed that in those sessions where volunteers from different backgrounds participated during the implementation of the UniX new workshop, volunteers relied on each other's expertise (either Math knowledge or general pedagogical knowledge), creating a positive synergy between them. For us, these collaborations constitute another of the extra values of the UniX volunteering program, which should be exploited in the future.

RESULTS OF THE IMPACT OF STEAM4U TRAINING ON 12-13-YEAR-OLD STUDENTS

A total of 60 students from 4 different secondary schools (30 females, 28 males and 2 No-Answer) participated in the pre-workshop questionnaires, and a total of 45 students from those same schools (21 females, 16 males and 8 NA), answered the post-workshop questionnaire. Questionnaires allowed us to track a number of 38 students (21 females, 16 males and 1 NA) having answered both pre and post-workshop questionnaires. All these students were between 12 and 13 years old and came from socially deprived backgrounds[6].

Different tendencies have been observed among boys and girls along the implementation of the new UniX workshop in terms of self-efficacy and, in particular, related to the use of Maths in school contexts or in everyday activities.

Impact on students' self-efficacy in Math in school contexts

The perception of Unix volunteers on the impact of the implementation ascribes an improvement of students' self-efficacy in Maths for all participating students, as a volunteer expressed in the interview:

> The main benefit of the UniX workshops for the students is that they raise their self-confidence in Maths. At the beginning they come saying that they do not know anything about Maths and, as you walk with them, they realize that they are able to do it.

However, data gathered from boys and girls before and after doing the workshop showed differences among them (Figure 22). According to data, at the beginning, boys seemed to feel much more confident than girls about their abilities: less than 20% of boys felt little capable on maths while more than 45% of girls felt the same. These behaviour, in which girls assess their Maths abilities lower than do boys, have been extensively reported in the literature (Bøe & Henriksen, 2013; Hill, Catherine, Corbett, & St. Rose, Andresse, 2010). These differences are commonly explained as girls holding themselves to a higher standard than do boys, believing that they have to be exceptional to succeed (Hill, Catherine et al., 2010).

6 The average level of studies of their parents, considered a strong predictor of the socio-economic level of students, was *secondary studies finished*. The average of the parents' level of studies from Catalonia population (data from PISA 2015) is *Bachelors' degree*, 2 categories above of the UniX sample.

On the other hand, the effect of the implementation also shows strong gender differences. By the end of the intervention, self-efficacy beliefs regarding maths showed to be in the upper scale of confidence. That is, both boys and girls felt very or somewhat capable, and there were no students feeling little or no capable. Due to the differences in self-efficacy at the beginning between boys and girls, girls’ final self-efficacy experienced a greater improvement along the intervention, compared to boys.

Despite this positive effect of the intervention in diminishing low levels of self-efficacy, the % of boys that rated their capacity really high (very capable) does diminish along the intervention. This fact, again, could be explained by the tendency of boys to overestimate their capacities before they actually experience the implementation. At the end of the activities, they would have more evidences to realistically rate their own performance. It is important to note that levels of self-efficacy in Maths at school appear to be similar between boys and girls at the end of the implementation.

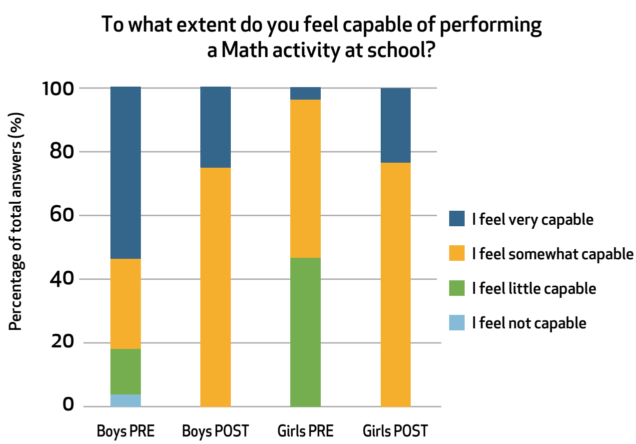


Figure 22. Differences between boys and girls self-efficacy at school.

Interestingly, when interviewing students about the workshop, we found that many students did not have the feeling they had learned Math content during the workshop:

> 3D and 2D are not Math content, but I have learnt many things I did not know.
> After participating in the UniX workshop I do not feel more able to do Maths in class, because the problems we do there are different.

These perceptions made us rethink the impact of the workshop on students' change of self-efficacy in Maths reported in Figure 22 to consider other possible factors that may have an effect on it, such as the work at school, volunteers' helping with the homework, increase matureness of students, etc. But especially, these perceptions pointed out an important consideration: when designing innovative Math activities that are very different from traditional school ones, Math topics can be hidden by the dynamics of the activity. Thus, volunteers need to make these contents explicit and connect them with the school curriculum in order to make students more aware of their math learning.

In addition, and based on the experience, we also believe that students would benefit more from carrying out workshops directly related with the Math topics students are working in school at the time, so that these connections are easier to be made. In this way, students would realize that Math can be learnt and done in a different way, breaking the negative association caused by their school experience, and helping them reduce their assessment anxiety.

CONCLUSIONS

The design, implementation and evaluation of the training of volunteers and UniX workshop provided some evidences of the potential of out-of-school activities to raise self-efficacy in Maths. The training, based on the *Teacher noticing* methodology (Sherin et al., 2011), was highly appreciated by the volunteers. In particular, the use of real examples of episodes of the implementation of the workshop allowed the volunteers to engage in meaningful discussions about teaching strategies to promote Math competences and raise self-efficacy in their context.

At the end of the training and implementation, volunteers coming from Social Science degrees experienced a raise in their self-efficacy beliefs about Maths. These volunteers acknowledged the low entry level of the UniX workshop, the key messages of the trainer and the quality of the teaching materials, as strategies helping them to raise their confidence. However, this increase of self-efficacy was narrowed to the particular Math content involved, so views of the SS volunteers about their own capacities in the Math area did not change. These evidences confirm that self-efficacy believes are deeply rooted in past personal experiences, and suggest that many different actions need to be undertaken to effectively change them.

Volunteers coming from STEM degrees (Science, Technology, Engineering & Maths), whose initial self-efficacy beliefs in Maths and Math teaching were high, become more aware of the concrete competences needed to teach Maths, despite no impact in their self-efficacy of Math teaching was observed. Conversely, although SS volunteers felt insecure about teaching Maths, once they felt confident about the Maths contents the development of their self-efficacy for teaching Maths was fast. All these evidences prove us that the volunteer training was appropriate and served to help both STEM and SS volunteers, and that combination of both sorts of volunteers in the same school would be highly beneficial.

The enduring character of self-efficacy believes was also observed in the impact of the implementation on students. Results show a modest rise of self-efficacy in Maths, which is particularly relevant for girls'. Again, these results suggest courses of action for the future. On the one hand, the need to undertake many similar actions to truly improve students' own self-efficacy believes. On the other, the need to address weak points of the implementation, such as the need to make explicit the Math curricular content involved in the workshop, and the need to directly connect the UniX workshops with what students are doing in their lessons at school.

KEY MESSAGES FOR EDUCATORS

- **As a trainer, train educators who will implement STEM workshops according to their needs: educators coming from Social Science degrees will benefit more from discussing about the content as students themselves; educators coming from STEM degrees will benefit more from discussing about strategies to teach a particular STEM content.**
- **As an educator, make evident the Math content/ competences involved in any innovative STEM activity, connecting it with the traditional curriculum. Otherwise, your students will mostly feel an increase of their personal abilities in general, but not a particular raise of their self-efficacy in Maths.**
- **Try to carry out diverse actions to raise your participants' self-efficacy in Maths, using a variety of strategies. Self-efficacy believes are deeply rooted and many different experiences are needed to change them.**

FUTURE STEPS

Non-formal educational contexts offer unique opportunities to develop Maths competences breaking the negative feelings that usually generate in school, in particular for students from deprived social backgrounds. From our experience, two considerations should be taken into account for future implementations. Firstly, in order to increase the impact of such initiatives in participants' self-efficacy in Maths, we need to better connect those experiences with what participants' do in their schools. By making evident the Math concepts involved in the activities and trying to carry out out-of-school workshops directly connected with what students are doing in their Math lessons, the impact on students' self-efficacy believes will increase more.

Secondly, the implementation of innovative activities pose some difficulties to new educators that cannot be ignored. As such, it is important to provide volunteers and other educators with a good training based on both subject matter and pedagogical content knowledge, balancing the weight of both according to volunteers previous expertise. Concrete and meaningful examples of the workshops, but also longer training efforts, should be considered to increase the impact of the training in both volunteers and students regarding the complexity of self-efficacy in maths.

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Curiosity, Self-efficacy & Informal Learning

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KEY FINDINGS

- **Informal learning provides unique and impactful opportunities to increase children's self-efficacy.**
- **Increasing facilitator's knowledge of self-efficacy helps increase the self-efficacy of children.**
- **Increased self-efficacy can be retained in children up to eight months after the initial experience of informal learning.**

IMPROVING SELF-EFFICACY OUTCOMES IN INFORMAL SETTINGS

Albert Einstein famously said:

> ""I have no special talents. I am only passionately curious."

There is a consensus amongst policymakers, educators and industry that science, technology, engineering and mathematics (STEM) engagement amongst the general public is crucial for future economic and societal prosperity (European Commission, 2015). An engaged public feels confident to:

- Understand the role of STEM in our lives
- Can judge between competing STEM arguments / engage in informed debate on STEM issues
- Encourage young people to study and work in STEM
- Engage with STEM research (SFI, 2012).

THE FESTIVAL OF CURIOSITY

- Designated as the official legacy project of Dublin City being the European Capital of Science in 2012, the inaugural Festival of Curiosity took place in 2013 and is Dublin's annual international festival of science, arts, design & technology.
- From Playful Days (family programme) to Curious Nights (adult programme) we create, produce & curate unique, visual and interactive cultural experiences in Dublin that merge cutting-edge technology, design, arts and science in playful, immersive & curious ways.
- With over 45,000 attendees each year across 14 venues in Dublin City Centre, the festival is Ireland's annual celebration at the intersection of art, science, technology and design and has quickly grown to be one of the most exciting and innovative festivals of its kind in Europe.

Self-efficacy is a component in STEM engagement and it influences behaviour in children selecting STEM careers (Bandura, 1993; Bong & Skaalvik, 2003). Building self-efficacy in families is a key step to becoming more curious as it gives people the confidence to ask questions, explore and create new solutions to problems we face in everyday life. Informal settings are becoming more and more important to achieve the goal of an engaged and scientifically informed public as they are platforms to engage families outside of the educational system and opportunities to improve STEM self-efficacy in children.

In Ireland, there are numerous educational-focussed initiatives that attempt to increase STEM subject engagement and uptake by students in the educational system, for example BT Young Scientist Initiative, RDS Science Blast, and Smart Futures. The need in Ireland has become a focus on building broader STEM engagement, especially in informal settings.

Figure 23. STEAM environanents at the Festival of Curiosity

Within this context, The Festival of Curiosity was created in 2013 and is Dublin's international festival of science, arts, design and technology. Over 45,000 people attend every year from around the world and it has engaged over 210,000 people since it began in 2013. The festival aims to give people the confidence and the tools to explore and create the future. Through over 100+ events every year the festival aims to create a culture of curiosity in society for young and old, allowing people to engage with the latest research in science and technology and helping them to see their place in an ever changing and uncertain world.

The creation of the festival was informed by the latest research on learning and education, which highlights the importance of character traits like curiosity, determination and self-control (Tough, 2013). These character traits are non-cognitive and have a direct impact on learning but also have a positive impact on memory and life satisfaction as we grow older. For example, neuroscientists at the University of California, Davis, conducted a study to test curiosity as a motivator of learning and to see what happens in the brain when curiosity is piqued. They found that people are more likely to learn and retain information when curious.

The key challenge at the festival is creating environments where young people can engage with Science, Technology, Engineering, Arts and Mathematics (STEAM) and build their self-efficacy beyond the festival. As the festival only takes place across a few days every year, the engagement time with audiences is limited. The challenge for the festival was to look at new ways to improve self-efficacy by improving the quality of the engagement with children and families.

INCREASING SELF-EFFICACY THROUGH QUALITY ENGAGEMENT

To understand the quality of engagement at the festival, an analysis of the audience journey was undertaken, especially for children. One of the major factors identified in the successful engagement of families was the interaction with the festival volunteers at our major events, such as the Curiosity Carnival. The Curiosity Carnival is an interactive science playground for all the family with over 4,000 families attending every year. The approach at the Curiosity Carnival is one of free play where children are encouraged to interact with installations and activities they wish to play with. The festival volunteers at the Curiosity Carnival act as facilitators helping guide the families through the experience. Improving the ability of volunteers to help identify and increase the self-efficacy of children would have a direct positive impact on those children.

Therefore, for the STEAM4U project The Festival of Curiosity decided to promote children's self-efficacy in STEAM through the improvement of volunteer interactions with families at the festival. We created a volunteer training video introducing volunteers to the concept of self-efficacy, helping them identify opportunities to increase self-efficacy at the festival and encouraging them to document observations each day of the festival.

Figure 24. Volunteers at The Festival of Curiosity

Parents are seen as direct influencers on children's self-efficacy and two extra actions were identified to help increase parents' ability to influence their children's self-efficacy at home. The first 'STEAM4U/Inspiration' is an online collection of photos that inspires families to see learning as fun and enjoyable and to increase their confidence to continue STEAM learning outside the classroom.

The second entitled 'STEAM4U/Home' is an infographic aimed directly at parents to inform them about the importance of self-efficacy and identify means to increase self-efficacy in the home.

Finally, to understand the nature of the impact of these actions on our target audiences, questions were integrated into the festival evaluation that helped understand the outcomes of the festival on the self-efficacy of families and volunteers. The evaluation took place during the festival, just after people attended events, and eight months after the festival to understand the longer-term impact of attendance on our audience.

ASSESSING THE IMPACT OF SELF-EFFICACY TRAINING IN INFORMAL SETTINGS - METHODOLOGY

There were two main audiences for the Self-Efficacy Action Plan undertaken by The Festival of Curiosity – festival volunteers and families attending the events - and the methodologies utilised to assess on the impact of the Action Plan are outlined below:

Volunteer Diaries

An online diary was provided to volunteers which allowed them to answer a short number of questions helping to identify when a child's self-efficacy had being positively influenced and what actions the volunteer took to increase the child's self-efficacy. The questions are listed below:

- Write down a positive memory from your time at the event today
- Write about any instances where you saw someone's confidence/self-efficacy positively impacted.
- Why do you think it increased their confidence/self-efficacy?
- From your perspective what do you think worked when you interacted with families?

The data was collected using the Survey Monkey and analysed one month after the festival.

Family Surveys

An evaluation of the festival is undertaken every year by Hope Stone Research, who work with a range of clients including The Gates Foundation, BBC Learning and the Museum of London.

Hope Stone Research undertook an evaluation in 2017 that analysed the impact of the festival on attendees in two stages:

Stage 1: Festival visitor survey

Festival volunteers conducted a survey of visitors (N = 150) across all days of the festival, 20th-23rd July 2017, using a printed questionnaire. The questionnaire asked:

- How visitors found out about the festival and whether they had visited before.
- Reasons for visiting.

- Attitudes towards science.
- The impact of attendance on attitudes to and understanding of science.
- Propensity to recommend to others (Net promoter score).
- Demographics .

Stage 2: Follow-up visitor survey

During March 2018 an invitation to complete an online survey was sent to visitors who had booked tickets online and had consented to be re-contacted. The follow-up survey aimed to identify the longer-term impact of festival attendance on adult and child visitors. It asked about recall of the festival and whether visitors had done anything different as a result of attending; for example reading more on the topics covered at the festival, attended other similar exhibitions, such as a science museum, or even started a course. It was available for completion between 26th March – 13th April 2018 and was completed by N= 151 people.

A key question was to understand the change in their self-efficacy or confidence at the event and also eight months after the festival.

ASSESSING THE IMPACT OF SELF-EFFICACY TRAINING IN INFORMAL SETTINGS - RESULTS

Festival of Curiosity 2017 Parent - "Attending the festival triggered an interest in my sons in how science and technology applies to everyday life after seeing it in action."

Volunteers

The key finding from volunteers was how important a positive and supportive attitude helped in increasing a child's confidence as they engaged with STEAM activities for example "I saw someone's confidence positively impacted when I told them about the things that he was very good at".

Secondly the facilitation of STEAM activities was important in allowing children to fail and re-try challenges and thereby giving them the confidence to explore on their own – "By giving initial instructions, leaving them to do the task themselves and then giving help when needed."

The qualitative findings of the volunteers' experiences support the literature on self-efficacy and highlights the importance of creating self-efficacy training opportunities for volunteers. The training of festival volunteers allows them to become part of a child's self-efficacy journey and positively impacts their confidence.

Families

As seen from the data below the positive effects of attending the festival has seen a substantial increase in attendee's self-efficacy and this impact was retained eight months after the festival.

IMMEDIATE IMPACT (AT THE FESTIVAL N= 150)

- **Relevant:** 89 percent of visitors agreed that the event made them feel that science is relevant to their life.
- **Curious:** 93 percent agreed that the event they attended made them more curious about science and technology.
- **Confident:** 79 percent agreed that attendance made them more confident to further explore science and technology issues and activities.

The follow-up survey provided evidence that many visitors went on to do something as a result of attendance.

- 80 percent talked to someone about their experience and 70 percent went on to find out more about the topic.
- 56 percent attended another STEM related event.
- 21 percent said they'd contacted an education institution about a course.
- Most of those in the follow-up survey who had accompanying children reported that their children had done something as a result of attending. 75 percent talked about their experience while 72 percent tried an experiment or similar.

LONG-TERM IMPACT (8 MONTHS AFTER THE FESTIVAL N=151)

- **Relevant:** 85 percent agreed that attendance had made them think science is relevant to their lives
- **Curious:** 90 percent strongly agreed that attendance had made them more curious about science and technology.
- **Confident:** 80 percent agreed that attendance had led to them being more confident talking about science and technology.

From the open ended questions in the post-festival survey, the different answers were collated into general actions and it was found that the festival also:

- Inspired children to do things, ask question, share experiences.
- Inspired parents to undertake activities with their children.
- Inspired and stimulated adults to do something new.
- Made science more relatable by seeing it in action in everyday life scenarios.
- Raised awareness of particular topics and stimulating conversation.

Figure 25. Parents and children learning together

CONCLUSIONS

Festival of Curiosity 2017 Parent - "[The Festival] Helped enflame an even stronger desire in my girls to follow careers in engineering and science."

Self-efficacy is a useful concept to help increase STEAM engagement with children in informal settings. It helps create action-oriented plans that can be implement and assessed to help improve the positive outcomes of STEAM initiatives.

KEY MESSAGES FOR EDUCATORS

- **Create playful environments for positive STEAM engagement for all**
- **Provide children with the tools not the answers**
- **Give children the confidence to try and the confidence to fail**

From the experience of The Festival of Curiosity it can be seen immediately that informal learning experiences have positive outcomes on children's self-efficacy. These outcomes can last for a long period after the initial experience and it is important for policymakers to see the role that informal settings can play in science education strategies.

The simple self-efficacy training provided to volunteers at The Festival of Curiosity helped them to become more self-aware of their actions and identify opportunities to improve self-efficacy as they interacted with children and their parents. The training can be developed with feedback from users to continuously improve the outcomes on volunteers and ultimately the children they engage with.

Looking at how families engage with STEAM in informal settings, volunteers/facilitators have a crucial role to play in creating opportunities to increase attendees' self-efficacy. The use of online training means that a large number of volunteers/facilitators can be trained without a large cost and it allows educators to create bespoke training for their particular initiative.

The challenge for all of us is to create positive and supportive environments for everyone to engage with STEAM and gives them the tools to succeed in STEAM and in life.

FUTURE STEPS

For educators in the formal and informal sectors, looking to replicate the impact of the STEAM volunteer training and improved self-efficacy on their initiative, they should look to ensure that the design of their engagement is structured around improving the self-efficacy of attendees, with a key focus on the needs and interests of the audience.

Educators could start collecting simple feedback on the elements that have the largest positive effect on self-efficacy and then look to begin training for volunteers/facilitators on the concept and application of self-efficacy in informal settings.

Once the initial pilot is complete they could expand the training and data collection to look at the longer-term impact of the initiative and build a robust understanding of how their STEAM initiative connects with other initiatives in the local ecosystem, so that audiences can be guided to other STEAM opportunities, building STEAM engagement across the broader community.

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What factors can make children more confident about their capacities in STEM? Role modelling and key messages provided by the experts of the workshop

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KEY FINDINGS

- **Children pointed out that the possibility to work in class using different methods than the conventional school ones improved their self-efficacy. Thus, we may say that active participation and use of different methods are most important to them.**
- **It seems that meeting scientists at the Children's University is something they could get used to but this factor does not have such a considerable impact on their self-efficacy**
- **Both girls and boys noticed that their perception of their skills changed as the result of the course. We have noted that boys used the phrase "I feel uncertain" less often in their post-test than in the pre-test. However, in the case of girls such replies were either unchanged or appeared slightly less often. The group of girls who described themselves as "unsure" can thus be the one that benefits less in terms of their own self-efficacy and for whom it might be more difficult to change the assessment of their skills.**

HOW WE CAN MAKE CHILDREN MORE CONFIDENT ABOUT THEIR OWN SKILLS IN STEAM AREA?

During this school year 8,500 children attended workshops and lectures organised by the Children's University. As organisers, we are fully aware that the children come to classes with different attitudes and expectations towards the courses and they also differ in terms of the perception of their own skills. Our participation in the STEAM4U project brought our attention to the construct of self-efficacy and encouraged us to seek ways in which we could improve the children's perception and appreciation of their own

CHILDREN'S UNIVERSITY FOUNDATION

- Since 2010 the Children's University Foundation organises Saturday workshops and lectures for children conducted by scientists and specialists in different fields. Through these workshops we would like to show the children and teenagers that the world of science and science itself are intriguing and open to everyone. It is our mission to develop children's creative and intellectual potential so that they can better understand and function in the world around them using their talents, knowledge and potential.

skills. We have asked ourselves if our courses included aspects which would need further improvement and development so as to let the children feel that they can work well in the STEAM area.

The concept of self-efficacy is rather unknown in Polish education and there is still too little attention paid to motivation for learning and its components. One of the motivational building blocks is self-efficacy which can be defined as a perception or awareness of one's own capabilities. Thanks to reinforcing self-efficacy children develop a feeling that independently of their sex, background, family financial situation or social capital they can pursue their education and reach out for knowledge that is thought of as reserved for special groups (e.g. IT for boys). Thus, young people come to believe that they can reach far, meet different challenges, and choose such educational or professional goals that are stereotypically assigned only to a select few.

In the Polish context seems that still not enough effort was put into education area to promote (e.g. by school's textbooks) such equity between girls and boys. As we can read in research's rapport analysing textbooks, a major part of school's textbook strengths gender stereotypes when it comes to occupation or social roles ("Gender in textbooks" project by Interdisciplinary Center for Gender and Identity Studies of Adam Mickiewicz University in Poznań, 2015, p. 7). According to results included in research's rapport in textbooks: "women are over-represented in professions related to office work, commerce or services" (Ibid, s.20). On the contrary men are more often shown as members of manger's teams or freelancers (Ibid, s.20). Stereotypical perspective included in textbooks can cause that girls will judge their capacities through stereotypical role models. Due to insufficient representation of diverse choices and social roles given by school education, it is necessary to take actions which help children estimate their capacities without stereotypical thinking and make them feel that they can do science even if this is thought of as reserved for special groups.

Without enough support of equity in science, the amount of women-scientist will be still underrepresented in Poland. Looking on the data provided by the Central Statistic Office we can observe that in 2005 49,5% of doctoral degree and only 36% postdoctoral degree were awarded to women of all that degrees (Central Statistical Office. (2007), Women in Poland, p.119). Of course, after more than a decade, contemporary data can be more optimistic but still seems to be a lot of work to do in that field. Changes can come both from formal and non-formal education.

We are aware that the Children's University courses offer not only educational potential through their use of the scientific method which allows children to learn actively but also to actually meet scientists. Therefore, it is both a challenge and necessity to support the lecturers in conducting classes for young people and to bring their attention to the fact that they not only shape the children's scientific attitude but also their ability to objectively assess their self-efficacy.

The Foundation's educational material prepared for the lecturers was a guidance how to act during their lectures. The material contained a presentation of a model for the classes but did not include indications as to educational strategies lecturers could choose or ways they could promote self-efficacy in children. Our activity within the project was aimed chiefly at the children: the classes were to give them a feeling that they learned something new and thus they developed their self-efficacy. The motivation provided by the lecturers, the way they invite children to work, guide them and comment on their mistakes or progress is undoubtedly a factor that could improve the process. Therefore, the project was also designed to include the lecturers as a group and to improve the teaching material so as to allow them to prepare better for their work with children. The material that was created as a result of this process is to a large extent universal because it can be used by all those educational professionals who want to incorporate promotion of self-efficacy into their teaching.

INTRODUCING STRATEGIES WHICH PROMOTES SELF-EFFICACY TO THE GUIDELINES FOR EXPERTS

During the workshops organised by the Children's University young students meet scientists and during their classes they assume the roles of researchers who explore a given area of knowledge. The time they spend with the scientists is on the one hand time with a different person than their school teachers and on the other an opportunity to meet someone who represents the actual academic world. By introducing the concept of self-efficacy, our participation in the STEAM4U project has also brought our attention to the importance of the children's development of their self-efficacy.

Figure 26. Team work during workshops about electronic

First, we diagnosed the aspects connected with the classes and co-operation with the scientists so that we could introduce strategies promoting self-efficacy. Following initial analysis, we identified the goals and the main challenges of the project. The areas we wanted to develop in our activity were the teacher-student relation and an improvement of teaching environment to positively motivate the students. Within the project we ventured to create a comprehensive set of educational materials that would prepare the lecturers to conduct classes with children. This would help them shape their attitudes and their communication in such a way as to reinforce the students' self-efficacy.

At the same time, we would like to learn if the way our workshops were conducted actually helped the children to come to the "I know I can" conclusion. Therefore, first we looked at all the existing material for the lecturers and discussed what type of content related to self-efficacy we could include in it.

Graphic guidance[7]

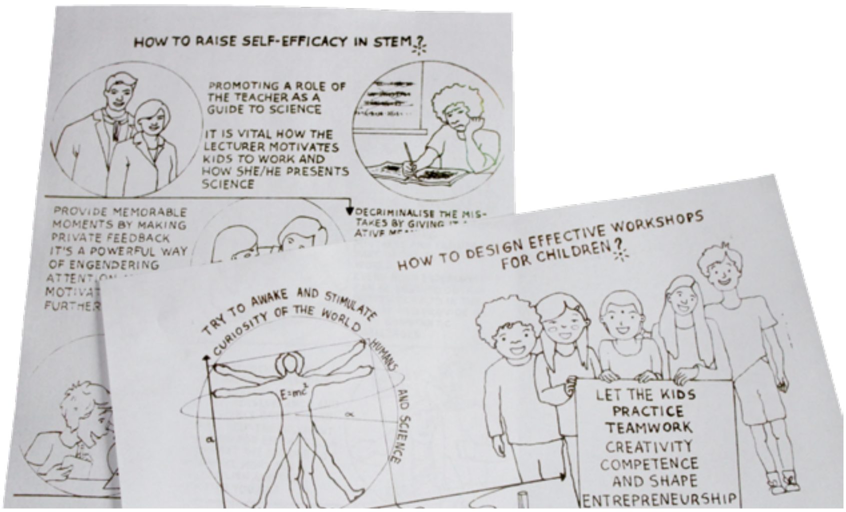


Figure 27. Fragment of the graphic guidelines for experts

As the result we created graphic guidance which familiarizes the lecturers with the building blocks of the Children's University workshops and which pictures the ways in which children's self-efficacy could be enhanced: through teachers' attitudes and feedback (e.g. how to praise or assess the students' work). The main challenge in developing this material was to "fit in" all the most important suggestions and advice which the lecturers could use during their work with children, and to "grasp" an universal perspective which would make this advice useful also e.g. for parents.

The project also included video material for the lecturers.

Video 1: "How to raise children's self-efficacy?"[8]

The video presents the notion of self-efficacy and how it can be promoted in children. It provides condensed information on how important it is for teachers to act consciously and be aware of the way they comment on children's work, praise it, and encourage children to further work while appropriately addressing their mistakes or failures.

7 http://steam4u.eu/wp-content/uploads/2018/07/graphic-guidelines_all.pdf
8 https://youtu.be/PYw-F2WR5-U

Video 2: "How to conduct lectures for children?"[9]

This video is based on actual lectures for children and lecturers' impressions following the lectures. The lecturers comment on their impressions and provide teaching advice. Thus, the material not only documents their thoughts but also provides space in which they can share their experience, show important aspects of the work and show what is important in speaking to children and what makes it more effective. The video can also provide inspiration for teachers to look for new, intriguing ways to present science to children by including experiments and examples from everyday life.

Video 3: "How to create science?"[10]

The project has also allowed us to produce a video dedicated for children. Together with one of the scientists we created a film in which the scientist tells the children about his usual work day but also explains what science means to him and what personality traits are important in the scientists' work. The main goal of this video is to show that the world of science has its own language which does not depend on sex or country of origin, and that the world of research is open to everyone.

All the videos are available on the Children's University Foundation's YouTube channel – with English subtitles

ASSESSING THE IMPACT OF THE WORKSHOPS AND MATERIALS FOR SCIENTISTS ON STUDENT'S SELF-EFFICACY IN DOING SCIENCE ACTIVITIES

(CARRYING OUT THE INVESTIGATION, SEARCHING SOLUTIONS FOR A PROBLEM, COOPERATING WITH OTHERS, PRESENTING RESULTS)

While working on the project, we have also evaluated our activities to see if the Children's University lectures and workshops increased the children's self-efficacy in different aspects. The materials we obtained as the result of this evaluation can be useful to the lecturers and can encourage them to use the suggested strategies in their work with children.

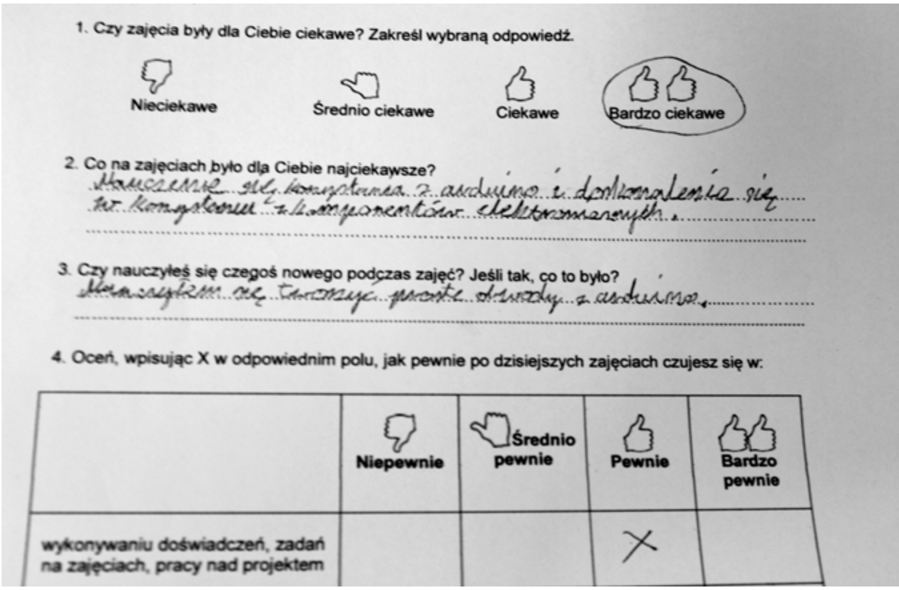
9 https://youtu.be/MZ5tFzCdW_4
10 https://youtu.be/y4AyYm4pUPc

Our self-efficacy test included: 192 children in pre-test ($N_{girls} = 73$; $N_{boys} = 119$), and 155 children in post-test ($N_{girls} = 60$; $N_{boys} = 95$) aged 12-13 years. The questionnaires they completed provided us with information on the changes in their responses. They also functioned as a tool with which our students could "monitor" their progress after the lectures. We distributed the questionnaires and collected the data in the first semester of the 2017/2018 academic year.

The questionnaires for the students and lecturers were created in cooperation with and with the help of our partners from the UAB. We produced our final version of questionnaires on the basis of the material provided by the UAB (suggested questions from the publications to measure the children's self-efficacy, questions derived from literature and other research projects).

We wanted to include questions which would refer directly to self-efficacy but also to select such questions which would be useful to our organization. Thus, the questionnaire included questions referring to the atmosphere in classes and what the children found most interesting, and direct questions about how confident the children felt in different areas (skills, knowledge). We tested self-efficacy in the context of the building blocks that constitute our classes. Therefore, we asked the children how confident they felt about: doing experiments and tasks during classes; project work; looking for answers and solutions in tasks and experiments; team work; presenting effects, conclusions and results of their work. The survey also included questions concerning the assessment of their own skills and knowledge of subjects connected with exact sciences and technology.

Before we introduced the final form of the questionnaire, we tested the questions and checked if the children found them understandable. Following the test we found out that open questions did not result in answers which would enable us to build categories for multiple choice and that the self-assessment scale had to be shortened so that the children could easily find the right answers. The test included 60 participants.



1. Czy zajęcia były dla Ciebie ciekawe? Zakreśl wybraną odpowiedź.

Nieciekawe | Średnio ciekawe | Ciekawe | Bardzo ciekawe

2. Co na zajęciach było dla Ciebie najciekawsze?

Nauczenie się korzystania z arduino i doskonalenie się w korzystaniu z komponentów elektronicznych.

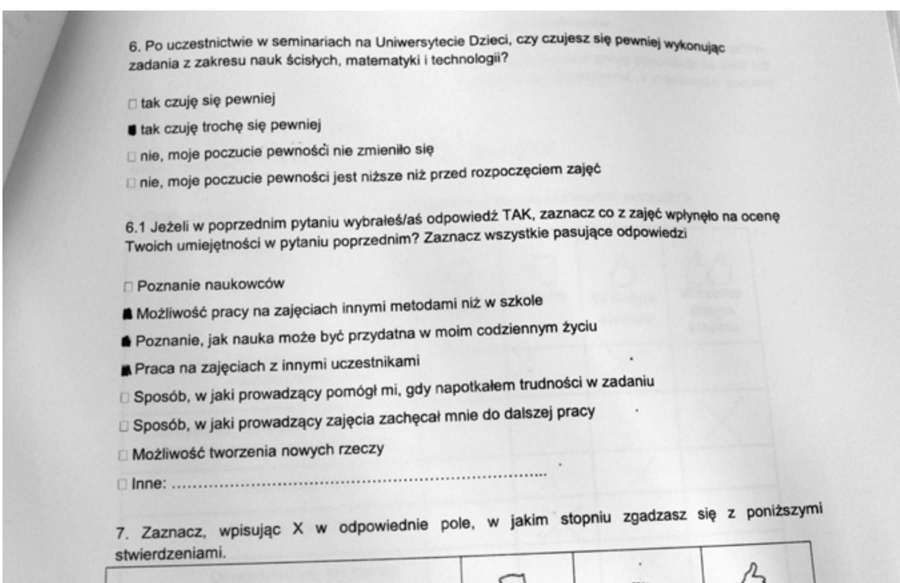
3. Czy nauczyłeś się czegoś nowego podczas zajęć? Jeśli tak, co to było?

Nauczyłem się tworzyć proste obwody z arduino.

4. Oceń, wpisując X w odpowiednim polu, jak pewnie po dzisiejszych zajęciach czujesz się w:

	Niepewnie	Średnio pewnie	Pewnie	Bardzo pewnie
wykonywaniu doświadczeń, zadań na zajęciach, pracy nad projektem			X	

Figure 28. Example of an answer given by student on question "What was the most interesting thing during workshop?"



6. Po uczestnictwie w seminariach na Uniwersytecie Dzieci, czy czujesz się pewniej wykonując zadania z zakresu nauk ścisłych, matematyki i technologii?

- ☐ tak czuję się pewniej
- ■ tak czuję trochę się pewniej
- ☐ nie, moje poczucie pewności nie zmieniło się
- ☐ nie, moje poczucie pewności jest niższe niż przed rozpoczęciem zajęć

6.1 Jeżeli w poprzednim pytaniu wybrałeś/aś odpowiedź TAK, zaznacz co z zajęć wpłynęło na ocenę Twoich umiejętności w pytaniu poprzednim? Zaznacz wszystkie pasujące odpowiedzi

- ☐ Poznanie naukowców
- ■ Możliwość pracy na zajęciach innymi metodami niż w szkole
- ■ Poznanie, jak nauka może być przydatna w moim codziennym życiu
- ■ Praca na zajęciach z innymi uczestnikami
- ☐ Sposób, w jaki prowadzący pomógł mi, gdy napotkałem trudności w zadaniu
- ☐ Sposób, w jaki prowadzący zajęcia zachęcał mnie do dalszej pracy
- ☐ Możliwość tworzenia nowych rzeczy
- ☐ Inne: ....

7. Zaznacz, wpisując X w odpowiednie pole, w jakim stopniu zgadzasz się z poniższymi stwierdzeniami.

Figure 29. Example of completed post-test questionnaire

The actual test consisted of three parts. During the first the students received a pre-test which tested their expectations and an assessment of their skills before the start of the course. Then they filled questionnaires after each lecture to test their impressions of the seminar they had just concluded. After the final class of the course the students filled the post-test questionnaire in which they assessed their self-efficacy in specific areas and which asked questions about what actually affected the children's self-assessment. We started the test at the beginning of our academic year and it covered seven different types of classes (topics connected with exact sciences, technology and engineering) in Wroclaw and Krakow.

The test aimed at collecting the lecturers' opinion on the graphic guidance and teaching strategies they considered important included 44 participants in pre-test, and 32 participants in post-test. Prior to the actual test we conducted a pilot survey among 15 scientists. The results did not show the need for improvements hence the initial questionnaire remained unchanged.

SELF-EFFICACY INCREACES WHEN THERE IS A POSSIBILITY OF CREATING NEW THINGS AND WORKING TOGETHER WITH THE CHILDREN OF THEIR OWN AGE

We analysed the collected data and divided the children's responses into two groups according to the sex of the respondents. Thanks to that we could check if the Children's University classes allow girls and boys to develop their skills and knowledge to the same extent.

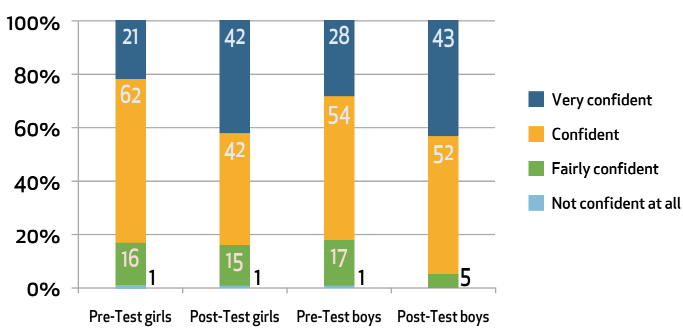


Figure 30. Graph showing the differences between answers given by boys and girls on question "How confident are you that you are able to do task and carry out the investigations during workshops?"

When analysing the answers we have to bear in mind that the numbers of participants of the pre-test and post-test were different: pre-test included 192 students (Ngirls = 73; Nboys = 119) post-test included 155 students (Ngirls = 60; Nboys = 95)

Following the analysis of how confident the children felt about doing their tasks during workshops we have found out that both girls and boys described themselves as "fairly confident" and "not confident at all" in pre-test but a considerable difference appeared in post-test when they chose "very confident" or "confident". In pre-test there is eight percentage points difference between the number of girls and boys choosing "confident". In the case of the "very confident" answer the difference is seven percentage points. On comparing the initial results with these in the post-test it is visible that in girls there is considerably more movement from the "confident" to the "very confident" group than in the case of boys. The change between "fairly confident" and "not confident at all" in girls is however rather insignificant. In boys, in the same category, the change is very significant as it amounts to 12 percentage points and the number of respondents describing themselves as "not confident at all" decreases dramatically.

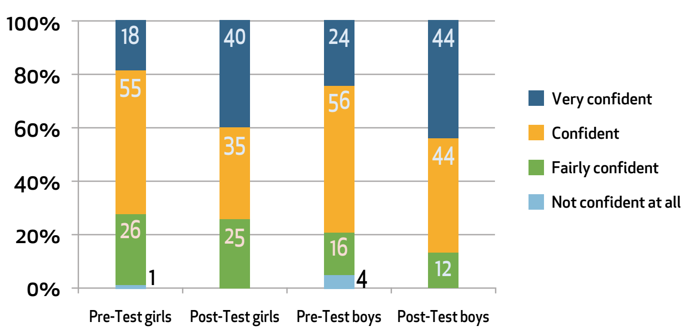


Figure 31. Graph showing the differences between answers given by boys and girls on question "How confident are you that you are able to search solutions for a problem?

The answers to the question how confident are you that you are able to search solutions for a problem show a similar tendency. The differences between pre- and post-test results in girls and boys are clearly visible in two aspects. The first tendency is a higher number of percentage points in the "very confident" category in girls: 22 percentage points whereas in boys the increase equals 20 percentage points. The second tendency is an insignificant change between "fairly confident" and "not confident at all" in girls – the declarations remain practically unchanged here. In boys though the "not confident" category disappears and there are less persons describing themselves as "fairly confident" in the post-test.

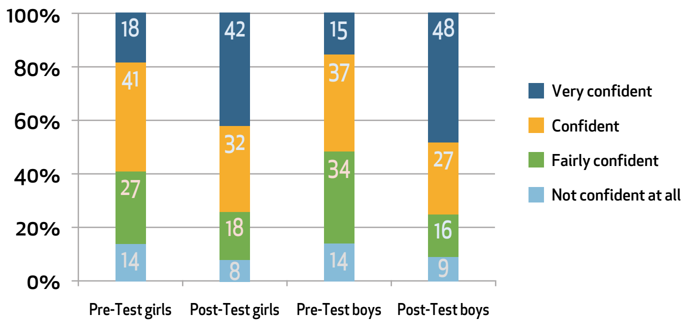


Figure 32. Differences between answers given by boys and girls on question "How confident are you that you are able to present effects of your work, results, conclusions?"

Answers to the question "How confident are you that you are able to present effects of your work?", do not differ between post- and pre-test with regard to the gender. Both boys and girls similarly described themselves as "not confident at all". Interestingly, it is the first area in which girls feel more confident than boys at the start of the course.

Another aspect we asked about in reference to self-efficacy was the confidence in team work i.e. a social competence which seems to be very important both at school and in professional or academic life. The answers show a tendency for growth between pre-test and post-test. Also the number of children selecting "fairly confident" decreases both for girls and boys.

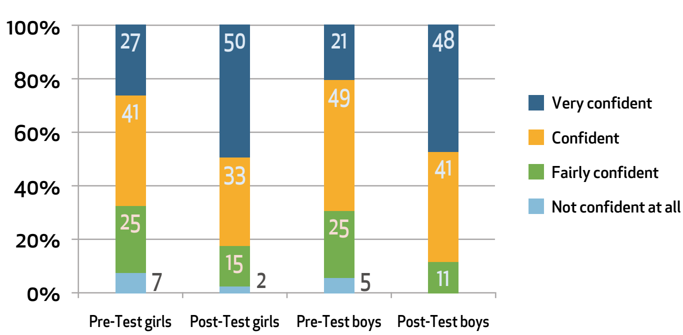


Figure 33. Differences between answers given by boys and girls on question "How confident are you that you are able to cooperate with others?"

To complement the presented data we also present the below graph which directly refers to self-efficacy. The answers to the question asked in the post-test provide information on how children assess their participation in the workshops and the knowledge/skills they subsequently gained. On looking at the graph we can see that boys more often selected "Yes, I feel more capable" than girls (a difference of five percentage points) who answered "Yes, I feel a little more capable" (the difference in this group is eight percentage points less for boys). In the context of the data analysed we can ask if girls are more "careful" for fear of overstating their skills and knowledge.

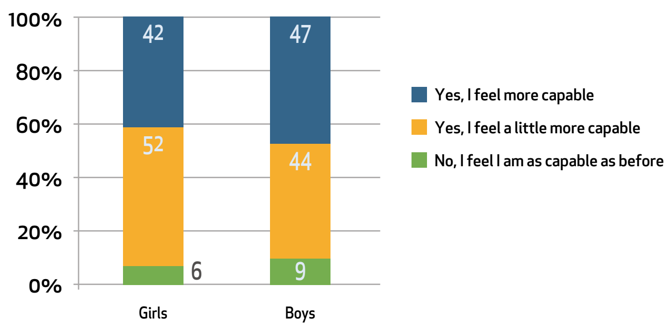


Figure 34. Graph showing the differences between answers given by boys and girls on question "Overall, and after participating in the workshops, do you feel now more capable of doing science activities?"

When analysing the answers to that question, we need to identify the factors which influenced the children's self-assessment i.e. what aspects of the Children's University workshops are most important in building their self-efficacy.

In post-test we asked children: "Which of the following characteristics of the workshop have made you feel more capable of doing science activities?". Thanks to the answers to this question we can identify the aspects of the workshops which are highly likely to influence self-efficacy. The answer selected most often was "doing science in a different way that at school" and "having the opportunity to create new things" as well as "doing science with my friends" – thanks to that we know that both methods and activities they engage in together with the scientists improve their self-efficacy. Less popular were the answers connected with the person of the scientist (the way they encouraged to overcome difficulties, ways to know the scientists). The students did not identify these as influencing their self-efficacy.

CONCLUSIONS

Our participation in the projects has mainly made us realise the importance of the notion of self-efficacy in education and the necessity to incorporate tools and content which can develop the children's confidence with regard to their own knowledge and skills during their courses at the Children's University. Self-efficacy testing was new to us and hence a challenge to develop good test tools and assessment. Our knowledge of whether self-efficacy increases in our students has allowed us to identify theses aspects of our courses which need improvement.

Following the experience gained in this project we know that it is worth to take up such tests and analyse their results trying to find out how to boost self-efficacy in boys and girls alike.

We are now more aware that self-efficacy in children increases when there is a possibility of creating new things and working together with children of their age. What's need to be emphasised is that education requires conscious actions and awareness of how teachers provide feedback on children's work, praise or encourage them and properly comment on their mistakes or failures

Thanks to the materials we have developed within the project and based on the feedback from the scientists we have learned that they appreciate our help in building teaching strategies and using different material (we used graphic guidance and videos). We also realized that the materials we produced could be used more broadly. It is another advantage of the project which enables us to broaden our initiative. During meetings with the parents of our students we presented the video introducing self-efficacy which parents found really informative and inspiring. Thus, we broadened the group of people familiar with the idea and inspired them to put it into practice.

KEY MESSAGES FOR EDUCATORS

- **One of the significant issue during teaching process is to foster children's beliefs in their own capacities in STEAM area – educator's attitude to student's failures or the way they wisely motivate children are the factors which can improve children's self-efficacy.**
- **We have to remember that science for children needs to be presented in an intriguing way including experiments and real-life examples to encourage them to broaden their knowledge and to show them the connections between science and everyday life.**

FUTURE STEPS

For us, as project partner and an educational organization results from evaluation are significant data pointing out to the strong points of the courses and they help us identify the fields which still need improvement in order to boost children's self-efficacy through different strategies and channels. Our effort in the respect will allow us to improve all aspects of the courses and we believe this will result in a greater number of participants feeling more confident about their STEAM competences. We hope that our experience from the project and knowledge we gained, will prove useful to other educational initiatives. We would like to encourage educators or organizations interested in replicating similar actions to take a challenge and focus on self-efficacy concept in their institutions. In such cases it is good to remember that fostering children's self-efficacy is a long-term process and it will not always be easy to implement all of planned actions. But still it is worth to put effort in it.

TO KNOW MORE

Interdisciplinary Center for Gender and Identity Studies of Adam Mickiewicz University in Poznan. (2015), Research Project "Gender in textbooks", Shortcut of the report, Warszawa: Feminoteka Foundation. Retrieved from http://gender-podreczniki.amu.edu.pl/

Central Statistical Office. (2007), Women in Poland, Warszawa: Statistical Publishing Establishment. Retrieved from https://stat.gov.pl/cps/rde/xbcr/gus/Kobiety_w_Polsce.pdf

"I didn't know my daughter was interested in technology" Promoting kids' self-efficacy in STEAM through the raise of familiar self-efficacy

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KEY FINDINGS

- **The use of STEAM-slick cards has an influence on the self-efficacy of the pupils.**
- **The increase in self-efficacy is higher for girls than for boys.**
- **Pupils experienced the use of the cards as enjoyable. They like talking about STEAM with their parents, and girls do more than boys.**

Gender imbalance in STEAM- education

Self-efficacy in STEAM refers to the belief in one's capabilities to accomplish a particular STEAM-related task at designated level. Self-efficacy influences students' behaviour when engaging and pursuing STEAM-related activities. Self- efficacy is a key component when promoting aspirations in STEAM (Bandura, 1993).

Earlier research has shown that the majority of young people has positive attitudes towards science at age 10 (Murphy, Beggs, 2005) whereas interest in STEAM declines the following years. Most young people, aged 10-14, have high aspirations for professional, managerial and technical careers but very few aspire to become a scientist.

THOMAS MORE MECHELEN, WIWETER ACADEMY

- WiWeTeR is an initiative of the Thomas More University College (Mechelen, Belgium). This initiative is aimed at promoting STEAM-activities for 10-12 year old primary school pupils, in several villages all over the Antwerp province. Every syllable represents a letter of the STEAM-word.
- WiWeTeR takes place after school hours (Tuesday evening 17:00-19:00 or Wednesday afternoon 14:00-16:00) and is carried out by volunteers or students. The students are trained and WiWeTeR is part of their teaching practice. A total of 120 pupils participated in the WiWeTeR.

Because of the widespread ideas about scientists, girls are less likely than boys aspiring science careers (Archer et al, 2013). Girls assess their abilities lower than do boys with similar achievements in STEAM subjects (Boe & Henriksen, 2013; Hill et al., 2010). Boys tend to be more confident than girls in academic areas related to science, technology and mathematics. These beliefs about their own competence, positively influences their real capacity in STEAM.

Archer et al (2013) notes that parental attitudes to science are related to aspirations in science. Families highly influence students’ aspirations, and that is certainly truer for girls than for boys. “Gender (being female) is also related to aspirations in science, but more weakly and in a negative direction (with girls less likely to express science aspirations than boys).”, according to Archer et al (2013, p. 12). Bian et al (2017) confirms these theses and notes that girls already at age 6 begin to avoid activities said to be for children who are really, really smart (p. 389). These findings have an effect on children’s interests and will shape their future career paths.

In Belgium, more specific the Flanders region, the different aspirations in higher education are also notable. Of the 166 students electronics-ICT at the Thomas More University-college (year 2017-2018) only 2 are female (1,2%) for example. Already in secondary education the shortage of girls in scientific directions grows. Because of the influence parents have on the aspirations of their children, it is important to involve them in the process of motivating children for STEAM. Thomas More has committed itself to create educational material to improve the image parents have of STEAM and to increase the self-efficacy of students when engaging in STEAM-related activities. When the whole family is engaged in the activity, the collective efficacy of the family and the efficacy of the students in particular will improve (Pajares, 2006).

Developing STEAM- slick cards to promote interaction between pupils and parents and to increase pupils’ self-efficacy

In order to raise pupils’ self-efficacy several actions were carried out: a design of a guiding letter, a design of STEAM-slick cards and a draft of a session for parents and pupils together (Serneels & Spruyt, 2017).

Guiding letter

Because the sessions of WiWeTeR are conducted by students of the teaching department it was necessary to inform them about the research. During the information session, September 2017, students received a brief explanation of the research. For more information at the start of the first WiWeTeR-session a guiding letter was developed.

This guiding letter consist of three parts: literature and framing of the research, the role of the Thomas More University College and an explanation of the methodology used for the research.

Figure 35. Children at work - Session Newton.

STEAM-slick cards

During the period of September 2017 – December 2017 two series of six WiWeTeR-sessions took place. The two series, called Newton and Joule, are similar in the way that all topics of STEM (science, technology, engineering and mathematics) are represented but the content is different. Each session is related to another topic.

During the sessions the pupils learn about the different topics; they explore, investigate, do experiments, build things... Involving families in STEAM- activities is a key factor for an increase in self-efficacy of the pupils. Thomas More University College developed STEAM-slick cards to promote interaction between parents and children.

For each session a card is developed. On the front side there are some questions about each session. For the session 'Electromagnet' for example these questions are:

'How does a Van de Graaf- generator works?', 'Why are you safe from lightning inside a car?' and 'How can you make electricity with a magnet?' The children know the answers because during the session they explored the topic and did some experiments. The goal is to challenge their parents to find the answer to the questions. They can talk about it in the car driving home or at the dining table at home. Children can show their successes and feel they are valued positively.

At the backside of each card there is a little fact or an experiment that they can do at home, together with their parents. It ensures interaction between parents and children. Depending on the card, they can find some extra information as well.

Figure 36. STEAM slick cards

These cards are collected in a bundle and locked together with a bus screw (Figure 36). Two extra cards were included; one with a brief explanation about the purpose of the cards and one with the website and contact information.

Session pupils-parents

For extra interaction between parents and children a session was developed where parents are invited to work together with their children (Serneels & Spruyt, 2017). For this kind of session it is important that the parents don't take the lead. At the start of the session the mentor has to take all the parents apart to talk to them and explain the purpose. It is a co-creation and children have to do most of the work. Because of the influence of parents on the self-efficacy of children it is important that parents know how they can react. When possible, parents have to confirm the children in their abilities in this way their self-efficacy in STEAM will grow.

The session consists of 7 parts in which the topic is situated, explored and investigated. Parent and child work together in pairs or sometimes they work with another parent-child pair. In the last phase there is a reflection about the session. Parents will also reflect towards their expectations, the collective self-efficacy of the pair and the self-efficacy of the children.

ASSESSING THE IMPACT OF THE STEAM SLICK CARDS IN PARTICIPANTS' SELF-EFFICACY

All pupils involved in the WiWeTeR-sessions were surveyed before and after their participation in the series, pre-and postquestionnaires (Figure 37). Because the parents had an important role in the interaction/participation with the cards, some off them were interviewed when they dropped of their children at the STEAM- session, Wednesday afternoon.

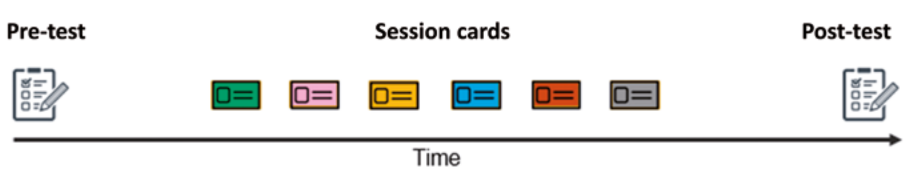

Figure 37. Timeline of the survey

Before the start of the first session all the pupils in both series, Newton and Joule, had to fill in the questionnaire (Serneels & Spruyt, 2017). The first part of the pre-questionnaire contains questions about STEAM- capital and expectations towards the sessions. The second part contains questions about the self-efficacy of the children before the interaction with their parents. According to Archer et al (2013) science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (p. 13). It is important to have an idea of science or STEAM capital because of the impact of the parents. A child from a family with a low science capital is less likely to aspire STEAM-related careers. When a parent has a degree level STEAM qualifications, a parent has a science career or shows interest in science, the science capital of the family will be higher (Archer et al, 2013).

During the sessions the children have to use the slick cards to interact with their parents.

To measure the impact of the STEAM slick cards all the pupils had to fill in a post-questionnaire at the end of the last session. The first part contains a reflection of the sessions: "What did they think of the sessions? What would they change?". The second part is similar to the pre-questionnaire. The questions have to be the same to compare the results of both questionnaires.

THE IMPACT ON SELF-EFFICACY

Data gathered by pre-and postquestionnaires provided a clear image of the impact of the use of STEAM-slick cards.

Overall picture

One of the goals of the pre-questionnaire was to have an overall picture of the pupils' participation in WiWeTeR. The average age was 10,4 years old. The youngest participant was 9 and the oldest was 12 years old. 134 pupils filled in the pre-questionnaire, the majority male (102) versus female (32) and 94 participants filled in the post-questionnaire.

Regarding STEAM-capital it is notable that a lot of children didn't know the degree their parents have (63,7%). Only 15% can say that the degree of their parents is a scientific one. Half of the participants never talk about science with their parents, 26% however talks about science with both parents.

This is remarkable because the majority of the parents seems to think that it is important to study science.

The participants have different expectations of the WiWeTeR-sessions (Figure 38). Some participants cross 'other'. The specifications are very divers, for example working with electric wires, learning more about science...

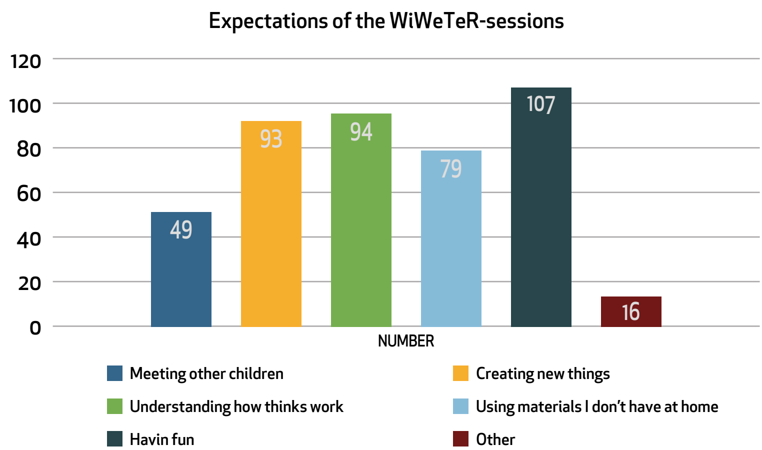

Figure 38. Expectations towards the STEM-academy

The effect on self-efficacy of the pupils

The pupils had to (dis)agree with a lot of statements in terms of self-efficacy in science, for example 'How confident are you that you are able to program?', 'How confident are you that you will be successful carrying out an experiment?' or 'I can work in group.' and 'I want to learn more about why things happen'. The general picture notes an increase of self-efficacy of the pupils.

For some statements like planning/carrying out investigations (Table 5) and applying mathematics in daily life (Table 6) the difference in self-efficacy is quite big in the positive way. The percentage of pupils answering 'I'm certain that I can do this' raises respectively with almost 10% and 14%. The increase is higher for girls than for boys (Figure 39). All girls indicate that they think that they can carry out investigations or that they are certain that they can carry out investigations.

PERCEPTION OF SELF-EFFICACY IN PLANNING AND CARRYING OUT INVESTIGATIONS	PRE-TEST (%)	POST-TEST (%)
I'm certain that I can't do this	4,5455	2,1277
I think I can't do this	17,4242	11,7021
I think I can do this	61,3636	59,5745
I'm certain that I can do this	16,6667	26,5957

Table 5. Perception of self-efficacy in planning and carrying out investigations

PERCEPTION OF SELF-EFFICACY IN APPLYING MATHEMATICS IN DAILY LIFE	PRE-TEST (%)	POST-TEST (%)
• I'm certain that I can't do this	• 3,8760	• 5,3191
• I think I can't do this	• 27,1318	• 10,6383
• I think I can do this	• 37,9845	• 39,3617
• I'm certain that I can do this	• 31,0078	• 44,6809

Table 6. Perception of self-efficacy in applying mathematics in daily life

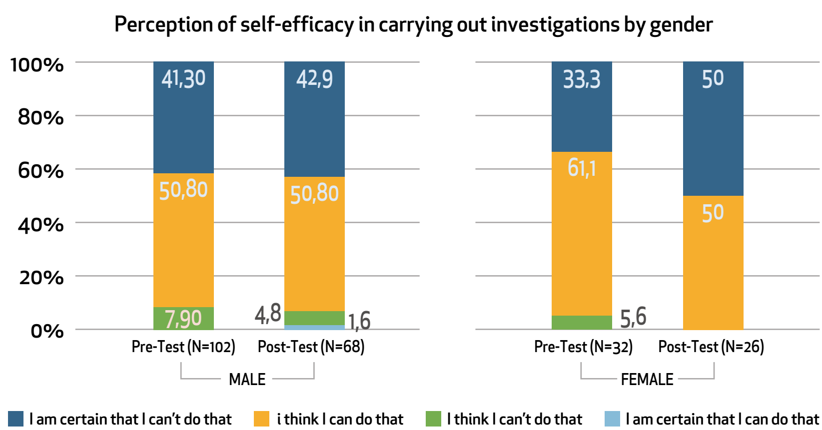

Figure 39. Perception of self-efficacy by gender

For the statement ‘How confident are you that you can program?’ the increase is very distinct. Probably a lot of children never had tried to program in advance. During one of the sessions and at one of the slick cards, the children learn how to program. This explains the increase. Still 14,74% think they can’t program. This is curious. Maybe they don’t realise they were programming during the session, maybe they weren’t present that time or maybe they aren’t sure about their skills in programming.

For some statements there is a stagnation. These statements, for example working in group or knowing their strengths and weaknesses, are very general and most of the times children have a clear picture of these abilities.

Working with STEAM-slick cards

Although the use of the cards was required, the pupils didn’t use them after each session. It is remarkable that girls are more dutiful than boys. The average use of the cards is different; 2,85 times for girls and 2,22 times for boys.

The perception of using the slick cards is also various. Girls like talking to their parents more than do boys (Figure 40). They think it is fascinating to know what their parents know about the topic, it is nice to talk about STEAM with their parents. When they answer ‘other’ they mention that it is nice to do some things together at home. Some of the pupils indicate that it is boring to do this. These answers are related with the age of the participants. The older pupils were not really interested in the slick cards. The reason is not very clear; maybe it is because they had to or they think it is boring.

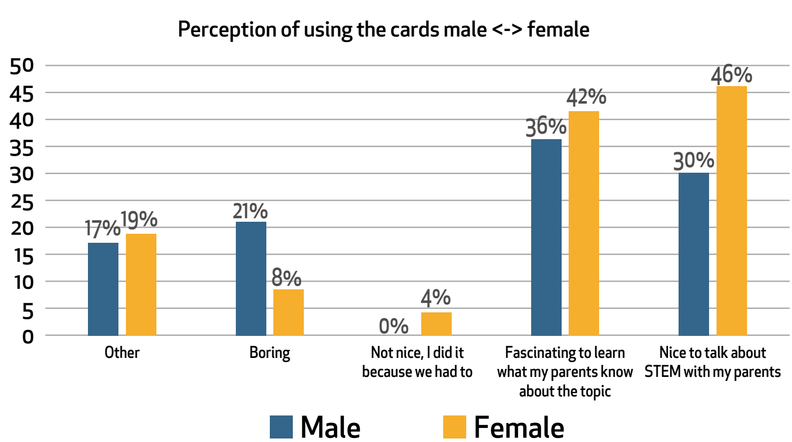

Figure 40. Perception of using the cards by gender

Interview with the parents

The WiWeTeR-sessions took place at Wednesday afternoon. Parents have to work and the children came alone to the session or together with some friends. It was very difficult to take an interview of the parents. Only 9 parents were interviewed.

2 out of 9 indicate they have a degree in science education. 7 parents mention that they talk more about science because of the sessions and the use of the slick cards (5 answer agree, and 2 totally agree). They tried doing an experiment, mentioned on the slick cards. 2 parents say they haven't done this.

The question "Do you notice a difference in self-efficacy in the field of science in your son/daughter?" was positively answered by the parents. Only one parent indicates that there is no difference.

Parents could also give some comments. One parent mentions that his son had more interests in science: "He talks about it when he arrives at home and he would like to study science in secondary school".

CONCLUSIONS

It is notable that the self-efficacy of the children aged 10-12, has increased during the period of September to December 2017. The use of STEAM-slick cards has proven to be effective, especially for girls who mention that they really like talking about STEAM with their parents and like doing things together with them. The older the children the less attractive the slick cards are. Also the parents are positive about the use of the slick cards. They see that their children are more confident in science, following the sessions and using the cards.

During the sessions it became clear that girls liked having female educators. One girl told an educator that it was nice to see a woman that likes doing science because her teacher at school doesn't like it and therefor they didn't do a lot of experiments at school. This statement emphasises the importance of female role models in STEAM education. For this girl there was no consequence on her self-efficacy but maybe for other girls this good have an influence.

KEY MESSAGES FOR EDUCATORS

- **Children, both girls and boys, like the interaction with their parents. Organising science activities at school where parents and children can work together is a key factor in increasing self-efficacy of the children and of the family.**
- **Using STEAM-slick cards or other materials to favourite the interaction between children and parents is a good work form.**
- **Already in primary schools it is important to realise that the self-efficacy in science is negatively influenced for girls. As educator it is important to show male and female role models and to counter the stereotypes where girls are confronted with.**

FUTURE STEPS

For those who want to implement the STEAM-slick cards it is important to consider the age of the children carefully. As said before the older the children the less attractive the cards were to use. In addition it is important to communicate with the parents about the purpose of the cards. Look for questions and experiments the children can easily do at home, experiments that do not take too much time and material that is facilely to find in a child-friendly environment.

In Belgium STEAM is present in most of the secondary schools and in several primary schools. The implementation though is different for each school and depends on the teachers. The framework for STEAM education already exists but there is a great need for a clear curriculum and final objectives for each year, developed by the government like the curriculum of other courses. This will give teachers a clear image of what objectives they have to achieve. In the curricula of the government there is also place for some didactical ideas or advices. Mentioning how boys and girls can be motivated for STEAM is an option. More space in the timetable to investigate, to explore and to design is welcomed.

The meaning of STEAM is not known by the big public, a lot of parents do not know what it stands for. At an evening information session of the school it is important to clarify what STEAM stands for. Teachers can explain how this will be implemented in class.

There are already lots of initiatives to counter the stereotypes in science careers. However it is necessary to keep looking for new initiatives. Organising more events where children and parents can explore together, can be successful. Bringing children in contact with people of the business world, of science labs or students in a STEAM education at university gives them an open mind about the content of STEAM studies and careers.

In comics the professor/laboratory technician is often a male with a white coat and a beard (for example professor Gobelijn in the comic Jommeke and professor Barabas in the comic Suske en Wiske). Girls are influenced by this image. Already at young age children have to be confronted with both men and women in science. A teacher can look into their books. Are there male and female researchers? Do you use he or she? (Frederix, S., 2017).

Creativity is a very important pillar of STEAM. Developing activities where creativity in science is a central factor can be useful. The way this influences the image that children have of STEAM can be the question in future research.

TO KNOW MORE

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