

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 manager'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 guidance⁷

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 ($N_{\text{girls}} = 73$; $N_{\text{boys}} = 119$), and 155 children in post-test ($N_{\text{girls}} = 60$; $N_{\text{boys}} = 95$) 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?
Ważenie się, komputera z Arduino i doposażenie się w komponentów elektronowych.

3. Czy nauczyłeś się czegoś nowego podczas zajęć? Jeśli tak, co to było?
Ważenie się tworzyć proste drzewo z Arduino.

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

	<input type="radio"/> Niepewnie	<input type="radio"/> Średnio pewnie	<input type="radio"/> Pewnie	<input type="radio"/> 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.

	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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 INCREASES 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.

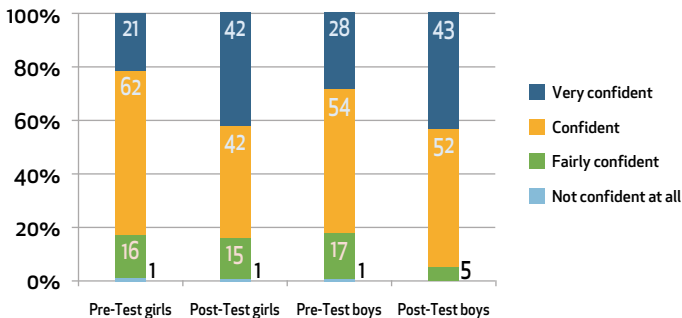


Figure 30. Graph showing the differences between answers given by boys and girls on question "How confident are you that you are able to do task and carry out the investigations during workshops?"

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.

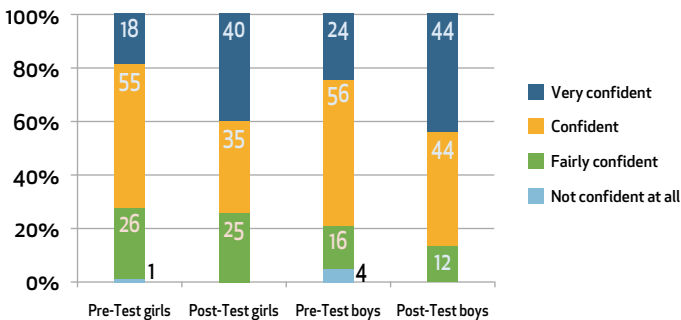


Figure 31. Graph showing the differences between answers given by boys and girls on question “How confident are you that you are able to search solutions for a problem?”

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.

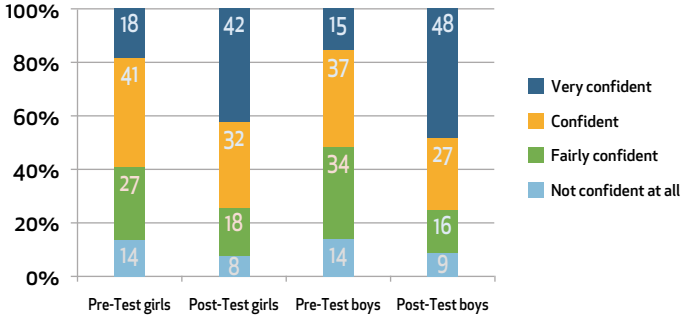


Figure 32. Differences between answers given by boys and girls on question “How confident are you that you are able to present effects of your work, results, conclusions?”

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.

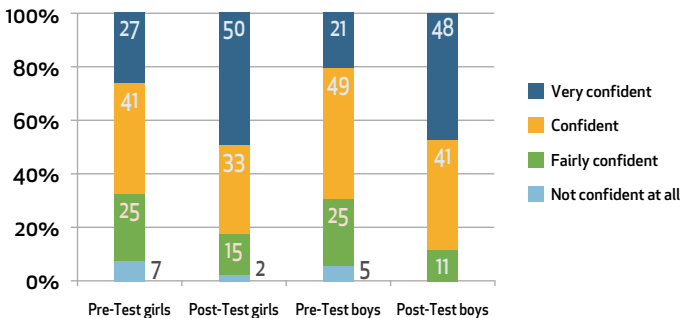


Figure 33. Differences between answers given by boys and girls on question “How confident are you that you are able to cooperate with others?”

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.

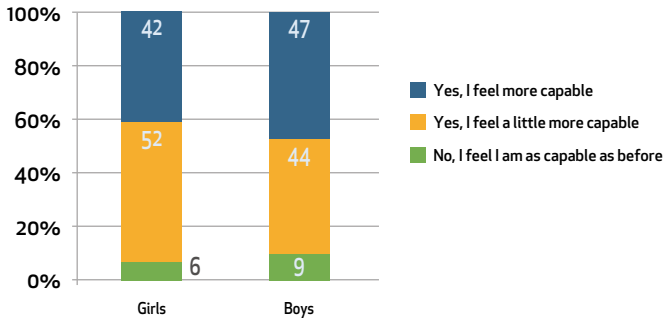


Figure 34. Graph showing the differences between answers given by boys and girls on question “Overall, and after participating in the workshops, do you feel now more capable of doing science activities?”

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 these 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