

"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.

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

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- 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.

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.

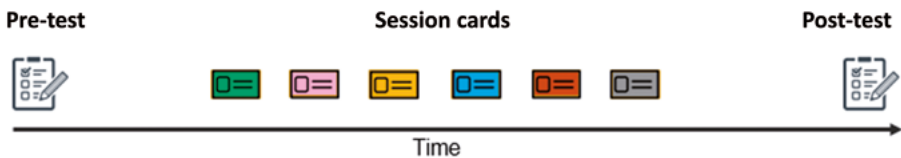


Figure 37. Timeline of the survey

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...

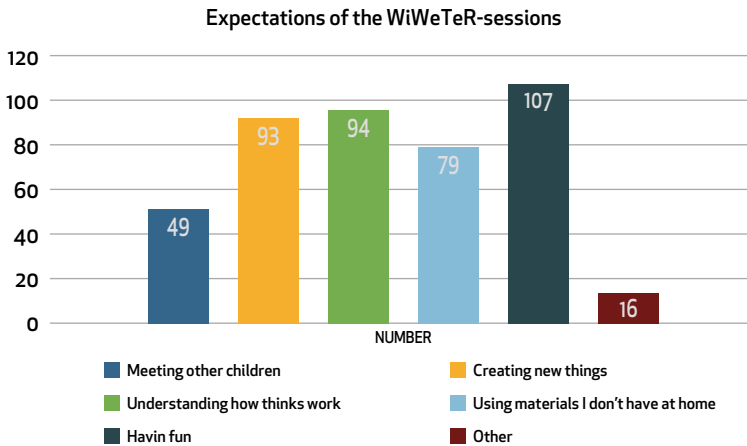


Figure 38. Expectations towards the STEM-academy

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

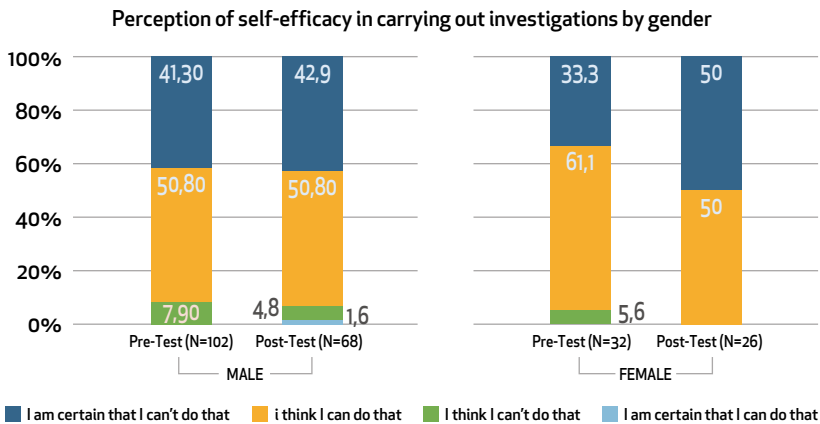


Figure 39. Perception of self-efficacy by gender

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.

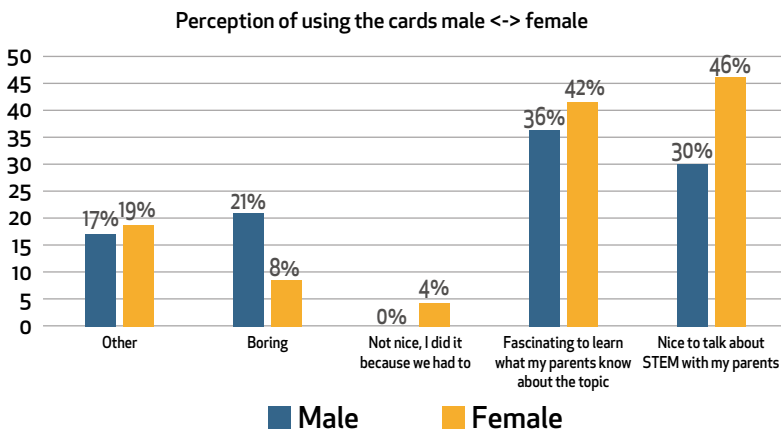


Figure 40. Perception of using the cards by gender

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 therefore 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 stu-

dents 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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