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Publication date
2019

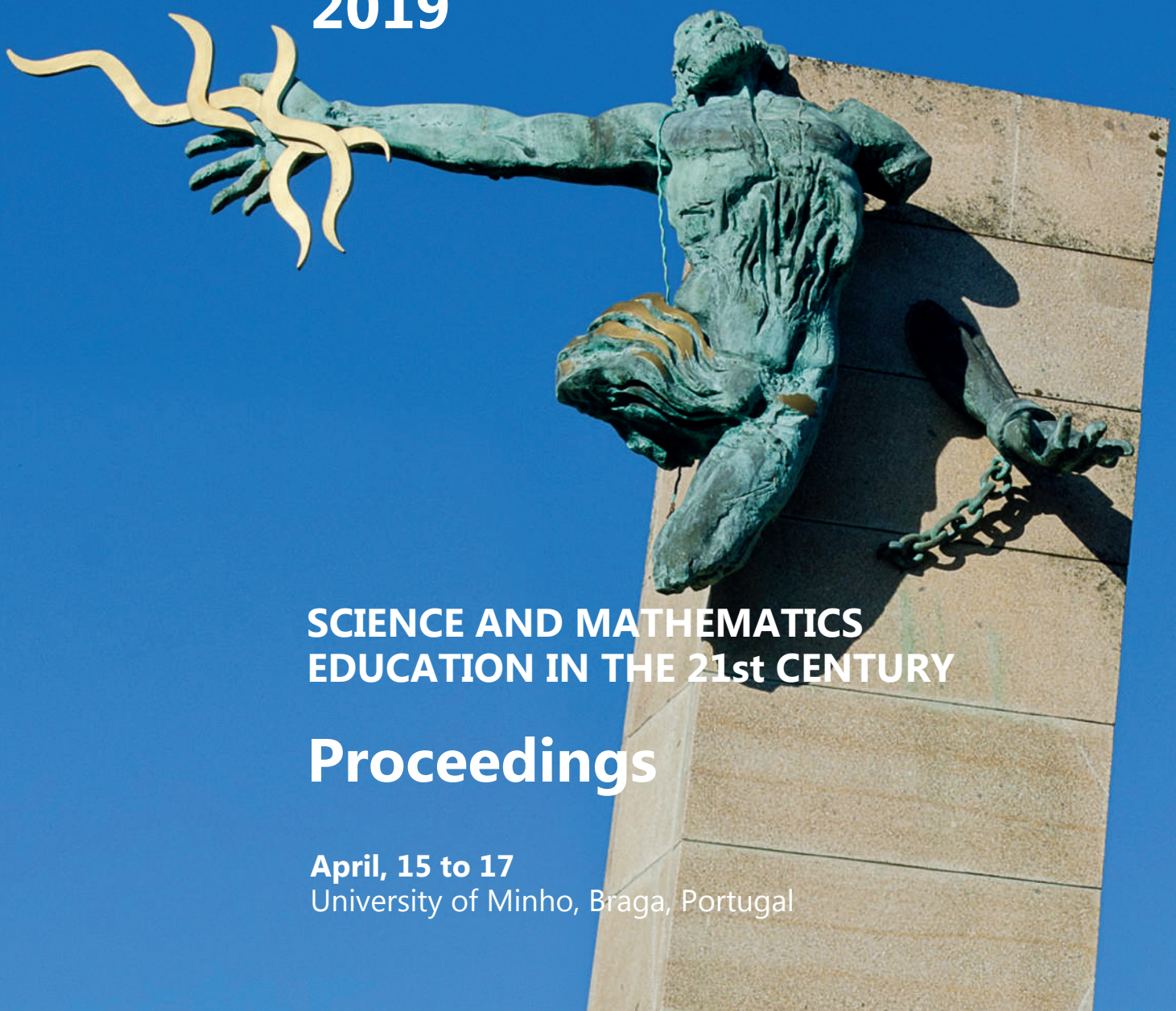
Document Version
Final published version

Published in
Proceedings of the ATEE Winter Conference 15-17 April 2019

ATEE

Association for Teacher Education in Europe

WINTER CONFERENCE 2019



SCIENCE AND MATHEMATICS EDUCATION IN THE 21st CENTURY

Proceedings

April, 15 to 17
University of Minho, Braga, Portugal

ATEE WINTER CONFERENCE 2019

Science and mathematics education in the 21st century

PROCEEDINGS

ATEE Winter Conference 2019 – Science and mathematics education in the 21st century

Proceedings

Published 2019

ISBN: 9789082506549

Editors: Laurinda Leite, Elizabeth Oldham, Luísa Carvalho, Ana S. Afonso, Floriano Viseu, Luís Dourado, Maria Helena Martinho

Cover design by Nicolau Moreira and Paulo Oliveira

Published by:

ATEE (Association for Teacher Education)
Brussels, Belgium

And

CIEd (Research Centre on Education - UID/CED/01661/2019**)**
Institute of Education, University of Minho
Braga, Portugal

L. Leite et al. (Eds.) (2019), Proceedings of the ATEE Winter Conference 'Science and mathematics education in the 21st century' Brussels: ATEE and CIEd (ISBN: 9789082506549)

Learning to enhance children's creativity in a makerspace

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Abstract: Maker education offers opportunities to stimulate the creativity of young people in various types of education. How to guide these learning processes, however, is an unexplored area for the supervisors (teachers and librarians). In the research-project presented, a professional learning community of librarians, teacher-researchers and maker educators investigates the pedagogy of 'making'. The learning community consisted of twelve makerspace-coaches, three maker educators and three researchers. The interventions for enhancing creativity that were developed varied from redesign of the tasks to new forms of guiding students. It was noticed that the children came up with new ideas and were motivated to push out their frontiers. Furthermore, the coaches experienced that children's creativity is not always visible in the final products of their making process, but rather in the process of making. The learning community turned out to be a fruitful approach for professionalization of makerspace-coaches.

Keywords: creativity; learning community; maker education

Introduction

In the past few years, 'learning by making' is finding its way in both primary and secondary education. Teachers discover new opportunities for inquiry, learning by design and integration with other subjects in maker projects (Martin, 2015). "Making" means an integration of creativity and new technology (3D printer, laser cutter, vinyl cutter, and more) and all possible other tools. This requires space and machines, which is a major investment for many schools. Public libraries see their task here to create makerspaces were school classes can come with their teacher and children after-school-programs (Slatter & Howard, 2013; Caso & Kuijper, 2019). These manufacturing locations can differ from each other on many points (Sheridan et al., 2014). Learning in a maker-space is anchored in the experience of making, with the process of tinkering, sorting out things, playing with materials and tools being of paramount importance. As a creator in these spaces, you need to find problems and projects to work on, join a community, take leadership or take a different role if needed and share creations and skills with a wider world. This requires a culture of trying out, asking questions and helping each other (Bevan, Ryoo, & Shea, 2017).

The present study focuses on the question of how these professionals can professionalize themselves to become "makerspace-coach", in particular with regard to stimulating creativity. We believe that the results are important for teacher educators because the professionalization of teachers into makerspace-coach will play a role in the coming years as schools expand their education with maker education as teaching for creativity is new for many (science) teachers and they lack skills to support children's learning processes in the maker space.

The aim of this study is to answer the following research question: How do

makerspace coaches learn to enhance children's creativity in a library makerspace by intervening in tasks, materials and guidance of the coach?.

This study is part of a larger project wherein learning goals in the makerspace - citizenship, empowerment and peer learning - will be explored.

Theoretical framework

Learning in the makerspace can be placed in the three target domains of education (Biesta, 2012), as shown in Table 1. First of all, there is the domain of qualification, i.e., the knowledge, skills and attitudes in the field of new technology and creativity. Children learn in the workplace to research and design and make use of digital manufacturing. Secondly, learning also involves socialization, where children are included in traditions and practices. On the one hand, these are the practices that relate to functioning as a researcher and designer, but also to democratic citizenship, which are involved in the environment. Thirdly, there is the domain of subjectification, of becoming a person in the world. That is about initiative, inspiration, motivation, and confidence in your own abilities.

Table 1. Domains of learning in the makerspace

Domain in the makerspace	**Learning goals**
Qualification - Technology and creativity	2D and 3D design, use tools, computer programming, to investigate, media literacy
Socialisation	Visualization and articulation of ideas, helping others and giving explanations, justifying your own work, being involved in a living environment, citizenship
Subjectification	Taking initiative, identity, self-confidence, self-efficacy, inspiration, enthusiasm, perseverance

Creativity in the workplace allows you to create meaningful objects or ideas in an original and personal way in freedom where the development of 21st century skills is central. Creators can show creativity in an increasing degree. It often starts with 1) learning to use technology (*reproducing*) then 2) introducing your own variation (*playing*) and even 3) trying new things (*experimenting*) up to 4) creating something new (inventing) (Loertscher, Preddy, & Derry, 2013). Characteristic for makers is the ability to improvise and put themselves in the position of future users of what they make (Teng, Chuang, & Hsu, 2015). Guiding children's in their creative process requires both restriction and openness, and room for frustration (De Jong, 2017).

Method

In the research-project presented, a professional learning community of librarians, teacher-researchers and maker educators jointly investigated the pedagogy of making. The learning community consisted of twelve makerspace-coaches, three maker educators and three researchers. The makerspace-coaches had been trained in digital technology and making in the past two years by the maker educators. Two of the researchers were self-taught makers. The makerspace-coaches provided programs in the makerspace for almost 60 children. The learning community focused during six months on the question how to enhance children's creativity.

Five monthly meetings of two-and-a-half hours were arranged in order to collaboratively: 1) Create a common framework of 'creativity in the makerspace' by integrating theory and experience from practice; 2) Develop interventions to enhance

creativity in the makerspace; 3) Perform the interventions and collect data; 4) Analyse results and formulate conclusions.

Data-collection consisted of reports of the five meetings, field-notes of the makerspace-coaches, pictures of children's artefacts, learner reports of the coaches and recording of the focus interview. The 30 children involved in this study visited one of the three makerspaces of the public library that was located in their neighbourhood. They followed a 12-week workshop on digital manufacturing. The majority of the children had followed one or more workshop(s) in the makerspace in the past year.

Results

The learning community

In this section, we discuss the results of the meetings of the Learning Community.

First meeting - A common definition of creativity in a makerspace

The coaches started with a brainstorm on the concept 'creativity' and made a mind-map on a large sheet of paper. Secondly, they were presented definitions of creativity from literature on little cards as shown in Table 2.

Table 2. Cards with definitions of creativity that were investigated by the coaches

Creative ability enables you to find new or original and applicable ideas for existing questions and is a combination of **originality** and **functionality**. (Buisman, van Loon-Dikkers, Boogaard, & van Schooten, 2017)	Creative ability = **Divergent thinking** (explorative, aimed at generating new ideas, solutions or alternative) + **Convergent thinking** (focusing on integrating new ideas or alternatives to a new approach or solution) (Buisman, van Loon-Dikkers, Boogaard, & van Schooten, 2017)	Creative thinking reflects the *original interpretation of experience*. Each of us has the capacity to construct original interpretations, and if it is a useful and original interpretation, it qualifies as "creative" (Runco, 2008)
The ability to be creative in a certain domain (science, arts, music, programming) is based on years of study and acquaintance of domain-specific skills (Sawyer, 2012)	Creativity is ' possibility thinking' with seven *habits of mind*: • questioning • play • immersion and making connections • being imaginative • innovation • risk taking • self determination (Cremin, Burnard & Craft, 2006)	

Thereafter, they discussed their mind-maps and reflections on the definitions. This yielded in the following findings.

- *Can creativity be taught? - Creativity cannot be enforced.* When exploring the notion of 'creativity' it first came up that it is hard to steer creativity, that one cannot 'grab' it, that one should not exert pressure, that it is important to give

space as much as possible. 'When it is obligatory, then I get blocked', told one of the coaches.

- *Creativity demands space to be 'different' and to 'make mistakes'.* Stimulating creativity has to do with generating trust and offer a safe environment. Creativity can be 'act silly' where it is important not to be laughed at. Being allowed to fail plays an important role. It was stressed that creativity is more a process than a product.
- *Creativity has both a functional and an artistic side.* On the one hand finding practical solutions, designing life-hacks and on the other hand creating, artistic, non-necessarily functional. One of the coaches mentioned that she entered the meeting with an image of creativity connected to arts, but that she came to the insight that it is linked to technology too.
- *Creativity is a collaborative process.* The coaches mentioned that many definitions of creativity emphasize the development of the individual, but that in a makerspace it is important to create *together*. This has to do with sharing knowledge and skills - an important aspect of the maker mind-set - but also with helping each other to generate ideas, or in a practical way. Another
- *Can creativity be taught? Sometimes it starts with copying.* A question that was raised: do we as makerspace coaches expect that children that come to the afterschool programs are creative or do we teach them to be creative? The experience is that children who are forced to come to the makerspace - this happens sometimes, since - are less easy to motivate and the coaches noticed that these children were mainly copying ideas from others.

The framework for creativity of Buisman et al. (2017) was discussed and adapted to the situation in the makerspace and provided with examples in the weeks that followed. In the end, this yielded in the framework 'Creativity in a maker space' as shown in Figure 1.

Figure 1. Re-design of the framework Creativity in a makerspace

The first column shows the five aspects of creativity with sub aspects (second column), and then each aspect is operationalized with behaviour (third column), an example from the maker space (fourth column) and how coaches enhance this children's behaviour (fifth column). As an example, the first aspect, curiosity (i.e. the first three rows of the framework) is shown in Table 3.

Table 3. The aspect 'Curiosity' from the framework Creativity in a Makerspace

Sub aspect	**Behaviour**	**What we see**	**Coach is doing**
Observing	Observes materials, tools and situations	*Child enters and observes creations* *Boy observes 3D-printer*	Draws attention to the environment of the makerspace
Questioning	Asks himself and others questions about making	*Kids ask which other activities take place*	Stimulates questioning
Investigating	Makes a brainstorm Looks beyond the first idea	*Kid searches on Google to ideas and connects this*	Stimulates research

The framework 'Creativity in a makerspace' was printed on an A2-poster that got a place in every makerspace as a reminder for coaches.

Second meeting - Pedagogy of creativity

In the second meeting the coaches gathered ideas on stimulating creativity with children. These ideas from practice were compared with pedagogical approaches from literature. We discerned interventions on three domains:

- *Makerspace environment* (materials, tools …)
  (5 times mentioned by coaches);
  - creating a safe and quite place, playing music
  - offering tools
  - showing the machines
- *Instruction materials* (open & closed tasks, manuals …);
  (7 times mentioned by coaches)
  - giving time for reflection
  - open tasks
  - starters, warming up
- *Guidance of the coach* (scaffolding, supervision …).
  (44 times mentioned by the coaches)
  - showing interest in the children
  - making them feel safe to express themselves
  - becoming friends
  - allowing to fail
  - stimulating ideas
  - stimulating interaction with peers

Third meeting - The interventions

The coaches selected one aspect of creativity from the framework and for each makerspace, a team of coaches developed an intervention to stimulate creativity. Two of the interventions that were developed:

- *Magic lantern: repeating the same laser-cutting task.* One of the coaches

signalled that children sometimes rushed through a certain task and then immediately continued with another project, while their creation could be improved. This coach intended to make children do the same task again in order to stimulate convergent and divergent thinking.

- *Superhero: an open programming design task.* The coaches noticed that many children performed instructions individually, but did not apply what they learned in an own design. They wanted to change this by a surprising design task. Aim of the intervention was to stimulate inventiveness during the programming course.
- *Ask questions.* Let children reflect on what they are making, by reflecting on this both at the beginning of the afternoon and by questioning them.

Fourth meeting - Results

- *Magic lantern.* The coaches stimulated the children on purpose to redesign their first artefact. About this, they report:

  "What happened with the kids when we gave them a second chance? The pictures speak for themselves. The children were freer in their second design. They knew better what was expected from them, they became freer in their head and they were less concerned with the process. This made them more creative and self-assured. We made lanterns with them. They were given an explanation about the technology with the projector beforehand and were shown a number of examples".

- *Superhero.* Upon entering the workshop, the children saw a picture of an exploded globe. The assignment for children was "Design a superhero who will save the earth". With the help of photos, the coaches have recorded how the children proceeded. Material for this was glue gun, cardboard, tape and of course Microbit. The coaches have taken photos (see for example Figure 5) of the four groups at work and children all came to an end product. The coaches wrote about this:

  "Based on the end product, it is difficult to establish ingenuity/creativity, we think the process says much more. The ambition of this assignment was quite high in terms of time, each group had an end result, but a few were not ready. More time may be needed to stimulate divergent thinking; to go beyond the initial idea. "

- *Asking questions.* The intention of this intervention was to let children reflect on what they do. When questioning the children, it appeared that children asked for guidance at that time. They wrote the following about this:

  "Children seem to have difficulty coming up with something to make themselves and ask the coaches for specific / directed assignments. Not being able to come up with a design or solution for a problem yourself often leads to frustration and sometimes "disruptive" behaviour. Reflecting is also visibly more difficult if no goal is set in advance. No matter how small that goal is. This has made us think further. Our main question has now become: How do you tap into the (natural) creativity and curiosity of children? What are good activating questions?"

Fifth meeting - Learning experiences of the coaches

The learning experiences of the coaches were inventoried during the last meeting of the design cycle on creativity. The evaluation consisted of two phases: each coach first completed a learner report and then two focus group discussions were held. The central questions during the evaluation were: what have the creative coaches learned about

creativity?; what have the job site coaches learned about guiding and promoting creativity in the job site?; what have the job site coaches learned from working in the Learning Community?.

The learner report consisted of nine open questions and was filled in by coaches during the meeting. Subsequently, two focus group discussions were held with the coaches simultaneously. Focus group 1 consisted of 6 coaches and focus group 2 consisted of 8 coaches. Each conversation lasted approximately 45 minutes. During the focus group discussions, the questions from the learner report were used as a guideline. These allowed coaches to further clarify the answers and discuss similarities and differences in learning experiences. The answers of the coaches are transcribed and analysed by horizontal comparison.

The coaches indicated that the different theoretical perspectives offered taught them that creativity can be defined in different ways. It appears to be a container concept and there is always some subjectivity, but that many coaches considered it to be measurable as an eye-opener. Several coaches also indicated that they are now more aware that creativity is something that you can learn and stimulate instead of a quality that you do or do not have. By formulating a definition of creativity in the workplace with all coaches, it was jointly experienced that the process is more important than the end product and that it is not only about making physical things but also about creating ideas. The coaches had also developed a framework for creativity in the workplace with concrete examples of creative behaviour. Most coaches perceive this framework as a good hold and it helps them to pay attention to specific behaviours in children that they would perhaps rather be less aware of. In addition, it was stated several times that the framework helped to structure the supervision. It should be noted that the framework was not always sufficiently applied in practice.

> "…all the theory and knowledge about it has helped me to recognize creativity earlier ..."
>
> "... I then started paying attention to things I hadn't thought of..."

Most coaches indicate that designing an intervention to promote creativity helped them to be more aware of their role and potential. They felt more capable of dealing with the different initial situations of the children and guiding them through a creative process. The joint design was experienced as very instructive. The implementation of the intervention and the associated data collection had also yielded several learning experiences. Several coaches pointed out that they had become more aware of the importance of a well-defined assignment. Too much freedom and openness can sometimes have a paralyzing effect on children because they are usually too inexperienced to get started themselves. Creativity is a process that you have to guide as a coach and most coaches indicate that showing examples is important here. In addition, it was clearly experienced that it is necessary for both coaches and children to have time to be able to iterate.

> "... time is very important, there was also a second group who took a lot of time and did it multiple times, so there was time to try it out and be divergent, to think up different things, to pick something out or add something. That is what we have learned: two hours is just too short, we were too ambitious, that is what we gradually found out... "
>
> "…We have learned to put it together, 2 hours is just too short, too much hay on the fork, you will gradually find out... "

The learning experiences of coaches with regard to guiding and promoting creativity in the workplace were largely the same. It was often mentioned that it is important to let children talk about what they are making and to ask the right questions. What is 'right' to ask differs in time and per person. The framework 'Creativity in a Makerspace' shows the various aspects of the creative process and how to guide them. In the beginning of the process, when a child has just entered the makerspace, it might be appropriate to raise curiosity and ask for children's experiences and wishes. In another phase it might be better talk about technical details. Consciousness of these aspects helped the coaches to formulate the 'right' questions. In addition, it was often mentioned that it is important to be positive, to motivate, to give good examples and to be a good example. Daring to let go of the planning was also often mentioned as an important learning experience. Dealing with children with specific problems, such as autism, was still experienced as difficult by a number of coaches.

> "… Asking the right questions, it was very useful for me to have those questions and to be aware of what do you want the child to learn and how and with the right question you can ask. That was really a Eureka moment..."

Most coaches indicated that they had learned a lot from the meetings of the learning community. The structure and structure of the meetings was clear and the personal contribution and discussions with each other are inspiring and make it very relevant. A few coaches indicated that they find this form of professionalization a clear addition to the existing offering because the emphasis is more on the questions about the "why and what" of the place of manufacture. The development of a joint professional language and vision was also mentioned as an important learning experience. It should be noted that it was an intensive way of learning that takes a lot of time, making it sometimes difficult to combine with other activities. In addition, there was a great diversity of views and experiences in the group, so that there are sometimes insufficient opportunities to delve into each other's situation and positions.

> "... lots of material to think about and become aware of and really practical tools. And also hear how others have that, otherwise you will have very little at that moment, then it will really be broadened, very pleasant ..."

Conclusions

The design research focused on the question how makerspace coaches can enhance the creativity in a maker space. This question was investigated in a learning community with maker space coaches and researchers. First, a framework for creativity in a maker space was developed. Secondly, the coaches developed interventions to enhance creativity.

They learned that creativity in a maker space:

- consists of in *many aspects*: observing (curiosity), questioning, investigating, making connections (inventiveness), convergent and divergent thinking, daring, creating, re-designing, reflecting, sharing;
- often becomes visible in the *process* of making than in the products children make;
- *can be enhanced* by the makerspace coaches. Creativity appeared to be measurable for the coaches and they experienced how to stimulate it. This was an eye-opener, since some coaches perceived it as a 'gift'. They became curious to get to know more of the learning process of the children in this aspect. Developing creativity and learning is important for children in developing their technological literacy.

(Future) teachers need to professionalize in enhancing children's creativity in their lessons.

The makerspace coaches experienced that collaborative design and investigations in the Learning Community helped them to learn how to better help children. The approach consisted of 1) creating a common ground with definitions of creativity from theory and experience in practice 2) checking the framework in practice and refining 3) developing interventions to enhance creativity 4) performing the interventions and collecting data; 5) analysing results and formulating conclusions. Step 4), however, which consisted of the process of data-collection by the coaches, was hard to combine with the organization of and responsibility for the program in the maker space. That is why, in the continuation of the project, researchers will mainly perform the data-collection.

What does this project teach us about the professionalization of teachers? Guiding creative processes requires a specific approach, which is new to most teachers. Going through the design cycle together in a learning community - as described above - appears to be a suitable way to learn this. In addition, it is important to note that prior to this study, the production makerspace-coaches at the library were trained in the field of digital technology and making, so they were trained as makers themselves. Both elements, self-making and learning to supervise the making of children are important for (prospective) teachers to make use of the makerspace in their education.

Acknowledgements

This research was funded by the municipality of Amsterdam as part of the project Maakplaats 021, carried out by the Amsterdam Central Library (ObA), Waag Society, Pakhuis de Zwijger and the Amsterdam University of Applied Sciences.

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