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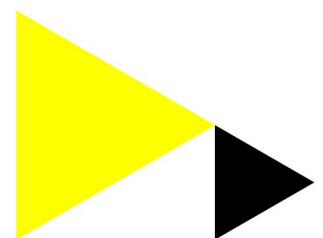
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Activities and Experiences of Children and Makerspace Coaches During After-School and School Programs in a Public Library Makerspace

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Abstract

Public library makerspaces intend to contribute to the development of children from marginalized communities through the education of digital technology and creativity and by stimulating young people to experience new social roles and develop their identity. Learning in these informal settings puts demands on the organization of the makerspace, the activities, and the support of the children. The present study investigates how children evaluate their activities and experiences in a public library makerspace both in the after-school programs and during school visits. Furthermore, it examines the effectiveness of the training program for the makerspace coaches. The study covers self-evaluations by children ($n = 307$), and interviews with children ($n = 27$) and makerspace coaches ($n = 11$). Children report a lot of experiences concerning creating (maker skills, creativity) and maker mindset (motivation, persistence, confidence). Experiences with collaboration (helping each other) were mentioned to a lesser extent. Critical features of the training program for makerspace coaches were (i) adaptation to the prior knowledge, skills and needs of makerspace coaches, (ii) input of expert maker educators, (iii) emphasis on learning by doing, (iv) room for self-employed learning, and (v) collaboration with colleagues.

Keywords Makerspace · Maker education · Informal education · Professional development · Self-evaluation

Introduction

Creativity, digital literacy, and collaboration are fundamental skills in modern society (Schleicher et al., 2019). Children and youngsters develop these skills not only at school, but also outside school in museums, clubs, and libraries. Many of these extracurricular resources seek to reach and emancipate minority groups, by offering

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an environment to engage with new technology and develop twenty-first-century skills (Bevan et al., 2020; Escudé et al., 2020; Lin & Schunn, 2016). These so-called *makerspaces* are accessible for children both during and after school, and seem promising for creating a bridge between formal and informal learning (Gahagan & Galvert, 2019; Nagle, 2020; Slatter & Howard, 2013; Willett, 2018).

In the period 2017–2020, the Amsterdam Public Library created Maakplaats 021, a *network* of ten library makerspaces throughout the city of Amsterdam, located especially in neighborhoods with a lower socio-economic status. Several activities for children were developed as well as a training program for staff. This project was realized in cooperation with three partner-organizations (Waag, Pakhuis de Zwijger, and the Amsterdam University of Applied Sciences). Similar initiatives (after-school tinkering programs for children from low-income families) have been developed in cities in recent years (cf. Exploratorium (Bevan et al., 2013) and the Bubbler at Madison Public Library (Halverson et al., 2017)).

The after-school program for children (aged 8–12) offered by the makerspaces of the Amsterdam Public Library included activities in the field of digital fabrication, tinkering, programming, creativity, sustainability, and citizenship. It was offered on weekday afternoons and during school holidays. Additionally, school programs were developed that focused on class visits during school time as a means to introduce pupils to the makerspace. Note that in the latter case, the initiative to visit the makerspace typically came from teachers.

The skills required by librarians to guide activities in a public makerspace differ quite from the skills required for their original profession. That is why many library makerspaces offer training programs for their staff. However, training of makerspace coaches is often minimal and good practices of training programs are scarce (Willett, 2018). For Maakplaats 021, training was developed in collaboration with the coaches and adjusted over time to accommodate the need of the makerspace coaches.

The aim of the present study is twofold: (i) it evaluates the activities and experiences that children report in the makerspaces of the Amsterdam Public Library for both school and after-school programs and (ii) it analyzes what it takes from their supervisors to support the learning of the children. The study distills critical features of education for future makerspace coaches that enables them to let children learn as much as possible in a makerspace.

Theoretical Framework

Learning by Making

Learning in a makerspace includes many facets, which differ from traditional education. Various frameworks seek to capture these broad domains of learning. They typically address (i) the creative part of making and the use of technology, (ii) the collaborative aspect of sharing knowledge and skills, and (iii) the personal element, i.e., the attitude in making (Bevan et al., 2014a; Cohen et al., 2017; Marshall & Harron, 2018; Martin, 2015).

A maker creates tangible objects using digital technology and craft tools. Digital fabrication tools enable “everyone” to become a maker and learning by doing offers new opportunities to learn. A makerspace allows to engage with digital fabrication tools and to be involved in creative projects that are typically not possible at home. Creativity can be stimulated by well-developed design assignments that focus on the use of digital technology (Chen & Lo, 2019). Making as a form of learning concerns playing and tinkering with materials and new technology, learning by doing, with an emphasis on developing creativity (Blikstein, 2013; Cohen et al., 2017; Marshall & Harron, 2018; Wilkinson & Petrich, 2014).

Being part of a maker community involves sharing knowledge, ideas, and skills. Sharing knowledge — both live and online — is inextricably linked to making, since the process of digital creation is often complex and many aspects of the software and skills are new. A maker shares what he or she knows and simultaneously consults other makers for information. This implies making contributions, asking questions, showing one’s own work, and responding to the work of others, by expressing appreciation and critics (Dekker & Elshout-Mohr, 1998). However, for young children in after-school settings, collaboration may occur more fluid. Learning together does not necessarily mean working on a joint project, but rather cooperating with others to realize and improve one’s own project. Also, in informal settings, the “nearness” of other kids can be meaningful, stimulating, and challenging (Bevan et al., 2013). Hence, diverse patterns of peer-collaboration — or social scaffolding — may emerge in a makerspace, ranging from “helping expertise,” “helping hands” to “exchange of ideas through the air” (Bevan, Wilkinson & Petrich, 2014; Halverson et al., 2018). Collaboration in a makerspace is not a means to learn, but a desired learning outcome in itself (Kumar et al., 2020).

The maker-mindset concerns playfulness, autonomy, agency, and persistence (Halverson & Sheridan, 2014; Martin, 2015). The use of new technology and materials, the freedom that children experience in a makerspace, all appeal to the *intrinsic motivation* of children: they are attracted and making means “fun” (Chu et al., 2017; Teng et al., 2015). In a makerspace, children learn to put their ideas into the real world and make them tangible, so that they literally get a better grasp of what they experience and what they think. Making promotes imagination (Katterfeldt et al., 2015) and agency (Halverson & Sheridan, 2014). The use of digital fabrication stimulates autonomy. Despite the many possibilities, making is not always “easy.” The digital design software and calibration of the machines require patience and persistence. The ability to deal with failures is an inherent part of the maker mindset and is promoted in many makerspace (Wardrip & Brahms, 2015).

Informal and Formal Learning in a Public Library Makerspace

Informal learning environments, such as museums, clubs, and field trips, may stimulate children’s motivation and foster a positive attitude towards science (Hurst et al., 2019; Julian & Parrott, 2017; Lin & Schunn, 2016) or offer youth opportunities to experience new social roles and develop self-confidence in science and technology (Sheridan et al., 2013). Informal learning is voluntary, takes

place outside of school in an open learning environment focused on personal preferences, and is free from formal evaluation. In contrast, formal learning is compulsory, takes place at school, is structured and standardized, and learning is formally evaluated (Rogoff et al., 2016).

How informal learning with an emphasis on creativity, play, and inquiry can be incorporated into formal education is still an open question (Oliver, 2016a). However, in order to advance the impact of informal STEM learning, it is important to “(1) integrate cognitive and learning science–based learning practices into informal learning contexts, (2) increase accessibility and diversity of informal STEM experiences, and (3) create explicit connections and coherence between formal and informal STEM learning opportunities in early childhood education” (Hurst et al., 2019, p.1).

Makerspaces in the public library may bridge the gap between formal and informal learning, functioning as a hybrid learning space where both extracurricular activities and school visits take place (Einarsson & Hertzum, 2019; Oliver, 2016a). Offering the same or complementary activities can strengthen the connection between school and after-school programs. Makerspace coaches and teachers can function as the linking pin by switching practices, sharing responsibilities, and clarifying each other’s roles (Fallik et al., 2013). Thus, a library makerspace has the potential of being a powerful learning environment for learning both during and after school.

Setting Up Public Library Makerspaces

In recent years, public libraries have created makerspaces (Chang et al., 2019; Julian & Parrott, 2017; Slatter & Howard, 2013; Willett, 2018), where children can get acquainted with digital fabrication, robotics and creativity. What does it take from public libraries to initiate a makerspace? Creating a makerspace requires more than placing machines. To successfully initiate a makerspace, libraries have to overcome five challenges. (i) Makerspace Layout. A makerspace generally consists of a 3D-printer, a laser-cutter, and a number of computers. In addition, digital tools such as a vinyl-plotter and electronics, and analog tools such as a glue-gun and a sewing machine are available. It is recommended to estimate which machines are relevant for each location, for example, in line with the specific expertise of the coaches on site. It is important to make a trade-off between placing a few expensive machines vs. more but cheaper machines. The layout of the makerspace should also be attractive to children who initially have little affinity with technology (Blikstein, 2018). (ii) Recruitment of Visitors. It is important to recruit the intended visitors. Public libraries are pre-eminently a place for children who do not encounter technology and creativity at home and/or at school, so these groups should be the focus. Makerspaces can fulfill a social function in the neighborhood and reach out to groups that are “at risk of being left out” (Brady et al., 2014; Taylor et al., 2016; Vossoughi et al., 2016). (iii) Valuable Programs. It is a challenge to teach children how to use the technology by offering the right activities and guidance (Prato & Britton, 2015). The question is what activities are suitable. Activities, tools, and materials depend

on the *goal* of the programs (creative expression, technological development...). Ideally, the activities and the use of materials align with the skills, preferences, and capacity of staff (Wardrip & Brahms, 2015). In after-school programs, flexibility is required to balance attaining learning goals and adapting to unexpected occurrences. This implies just-in-time instruction and room to experiment and play for children (Escudé et al., 2020) (iv) Training of Supervisors. Another challenge is staffing the makerspaces (Nagle, 2020). Makerspace coaches play an important role in the ultimate realization of a manufacturing site. They must be able to guide the children and design programs. To this end, coaches should be informed by the experiences of experts in this field and by existing theoretical insights (Willett, 2018). In addition to training, it is critical that coaches can collaborate (Moorefield-Lang, 2015). (v) Impact Assessment. Finally, it is important to measure the learning outcomes in order to evaluate the impact of a makerspace. To guarantee the continued existence of the makerspace, libraries must not only record visitor numbers but also gather data to assess and evaluate the intended goals of the makerspace (Nagle, 2020).

Setting up library makerspace puts high demands on the makerspace coaches. Thus, the question is what they have to learn and how this is done best.

Competencies of Makerspace Coaches

A library makerspace is brought to life by the makerspace coaches who work there and undertake activities with the children. They “collaboratively coordinate personal, social and material resources to establish a productive learning context and trajectory through making” (Brahms & Crowley, 2016, p.15). For library staff, this means a change from “providing information” to “promoting learning” (Koh & Abbas, 2015), which requires new competences and appropriate training (Moorefield-Lang, 2015). We consider five competencies of coaches that are central to working in a makerspace. (i) Point of Contact. Makerspace coaches are the “face” of the makerspace. They receive visitors, familiarize them with the machines, and ensure that visitors get started (Bevan et al., 2014a; Koh & Abbas, 2015; Lee, 2017). Makerspace coach approach children personally and often develop a bond with them (Brahms & Crowley, 2016; Lee, 2017). The contact with parents is also part of this (Brahms, 2014; Calabrese Barton et al., 2004). (ii) Being an Expert. Becoming a makerspace coach requires knowledge of the design software and the machines, including how to work with them safely. It requires being or becoming a maker oneself (Bevan et al., 2014b). For libraries, this means training of staff, attracting new people to serve as a makerspace coach, and collaborating with other organizations in the makerspace (Wardrip & Brahms, 2015). (iii) Activity Supervisor. Makerspace coaches offer activities that allow children to learn and guide them in making, which requires knowledge of pedagogy and didactics (Bowler & Champagne, 2016; Einarsson & Hertzum, 2019; Loertscher, Preddy, & Derry, 2013). This also includes stimulating interaction between children (Kajamaa et al., 2020). (iv) Educational Activities Designer. Makerspace coaches also initiate new programs in the field of technology and creativity (Koh & Abbas, 2015). In the role of educational designer, they develop activities aimed at the target group of the makerspace. Furthermore,

they document learning outcomes, both physically by exhibiting the created works and online with photos and videos. This requires skills for evaluating and assessing work (Oliver, 2016b). In some makerspaces, makerspace coaches also undertake acquisitions to finance the makerspace and arrange the planning of activities (Koh & Abbas, 2015). (v) Holding Responsibility. Above all, working in a makerspace requires flexibility, being able to respond to changing circumstances and being able to work well together (Koh & Abbas, 2016).

To develop their new professional competencies, library staff needs time and training (Moorefield-Lang & Coker, 2019), preferably in a professional learning community (Stevenson et al., 2019). Support and flexibility from the organization are indispensable in this respect (Williams & Folkman, 2017). Often, librarians are “thrown in the deep end” when they start as a makerspace coach (Moorefield-Lang & Coker, 2019). Moreover, it is currently unclear what constitutes an effective training of makerspace coaches in a library.

Research Questions

Public library makerspaces are promising learning environments for formal and informal learning. The realization of these spaces puts several questions, concerning the development of children and the professionalization of makerspace coaches. Guidance of the children is important, and since this is new to most librarians, the development of makerspace coaches needs to be investigated. Aim of the research presented in this paper is to evaluate children’s activities and experiences in a public library makerspace and to distill characteristics of effective training for makerspace coaches. This leads to the following research questions:

1. How do children evaluate their activities and experiences in the field of creating, collaboration, and developing a maker mindset? (RQ1)
2. How do makerspace coaches estimate children’s activities and experiences? (RQ2)
3. What do makerspace coaches (need to) learn in their training to support children? (RQ3)
4. What do makerspace coaches identify as critical features of the training for makerspace coaches? (RQ4)

Design

Project Maakplaats 021

The project Maakplaats 021 created makerspaces to serve the needs of under resourced communities. A *network* of ten library makerspaces was funded, located throughout the city and especially in neighborhoods with a lower socio-economic status. The administration of subscriptions for the after-school programs is carried out by makerspace coaches on each location, and children could subscribe by

e-mail. The children attending the after-school program were mainly living in the community, so the population of students served in this makerspace is focused on historically marginalized young people.

After-School Programs for Children The after-school programs in the ten public library makerspaces each consist of 12 afternoons for groups with a maximum of 15 children, averaging in of age 8–11 years. Each group is guided by two makerspace coaches. The programs concern designing (with help of freeware Inkscape, Tinkercad) for digital fabrication (vinyl-cutter, laser-cutter, 3D-printer) and programming (Scratch, Microbit, bots). They are designed around a theme, such as “Creating creatures” (i.e., making your own stuffed animal using a laser cutter, 3D-printer and sewing machine). Each period, the makerspace coaches develop new programs. Some programs include improvements for the local community, such as “Make our square” (i.e., designing improvements for a square in the community, based on ideas of community members).

School Programs for Children In 2019, school classes could visit the makerspace for 3-h sessions to get acquainted with digital fabrication. Since 2020, school classes (grades 3–5) could visit the makerspace for a series of 3-h sessions on digital fabrication, but also on learning by inquiry and design, sustainability, citizenship, and programming. For instance, one of the school programs in 2020 was about “Card-board Automata.”

Training of Makerspace Coaches Maker educators of Waag developed the training program for makerspace coaches. It consisted of a 2-day crash course, monthly meetings, and additional activities. Librarians starting to work in the makerspace took part in a 2-day crash course to get acquainted with the technology for digital fabrication and programming. This “Librarian Maker Camp” also prepared future makerspace coaches in designing activities for children (for instance tinkering activities). This 2-day course was repeated every year with the team of makerspace coaches and new colleagues. Besides this course, the makerspace coaches deepened their maker skills in monthly “Maker Mornings.” The training program further consisted of “Learning Community” meetings, where the link between theory and practice of learning and pedagogy in the makerspace was established: makerspace coaches, together with researchers going through the design cycle subsequently on the theme’s “creativity” and “sustainability,” and a symposium was organized on “subjectification” and one on “collaborative learning.”

The Study

The study used multiple data collections in order to answer the research questions posed. Data collections took place during school and after-school programs in 2019 and 2020 in the makerspace. The design of the study is shown in Table 1. The first and the second research questions are answered by self-evaluations of, and interviews with, children in the after-school and school programs. The third research

Table 1 Design of the study

Instrument	Respondents	Research question			
		1	2	3	4
Self-evaluations of children	$n = 307$	x			
Interviews with children	$n = 27$	x			
Interviews with makerspace coaches on children's learning	$n = 6$		x		
Interviews with makerspace coaches on their own learning	$n = 11$			x	x

question is answered by interviews with makerspace coaches about the children's learning. The fourth and the fifth question are answered by interviews with the makerspace coaches about their own learning.

Method

Participants

The children participating in the study ($n = 307$) attended after-school programs in the makerspace ($n = 169$) or took part in a school-program in the makerspace ($n = 138$). Children in the after-school programs (aged 8–12 years) lived mainly in the neighborhood of the makerspace, sometimes visiting the makerspaces for a couple of years. Children in the school-programs (aged 10–11 years) visited the makerspace together with their classmates and teacher. The children in the after-school programs that were interviewed ($n = 27$) were selected by convenience, since their parents' active consent was needed to record the interview.

The group of makerspace coaches grew with the stepwise realization of ten makerspaces (period 2017–2020). The project started with a team of six librarians in 2017, extended with librarians and other professionals (e.g., designers) in 2018 and 2019. In the summer of 2020, eleven makerspace coaches worked in the makerspaces.

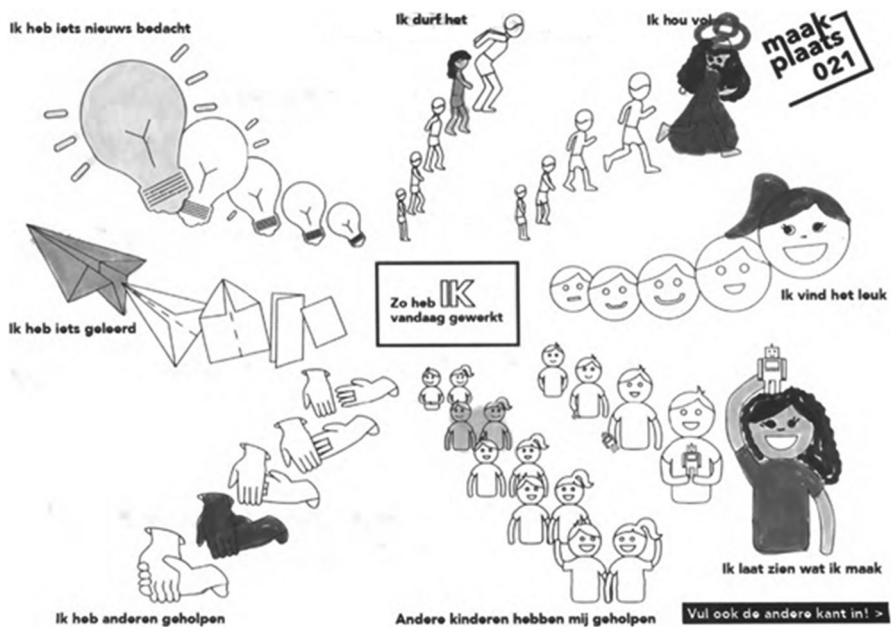
Instruments

Self-Evaluation Tool for Children (SET) To assess the learning goals of children in a makerspace, a Self-Evaluation Tool (SET) was developed and validated (van Eijck et al., 2018; Van Eijck et al., 2020). Learning in a library-makerspace was operationalized into eight categories with their associated items (Table 2).

The SET itself consists of a coloring sheet with eight distinctive series of easy-to-understand visual symbols that grow larger towards the periphery (Fig. 1) and a short accompanying text (Table 2, A–H). With this, each category has a quantifiable gradation from 1 to 5, allowing the children to score their own performance. The

Table 2 Operationalization of learning in a library-makerspace in the SET

	Category	Item
Creation	Creativity	A. I invented something new
	Maker skills	B. I learned something
Collaboration	Giving help	C. I helped others
	Receiving help	D. Other children helped me
	Sharing	E. I show what I make
Maker mindset	Intrinsic motivation	F. I like it
	Persistence	G. I persist
	Confidence	H. I dare to

**Fig. 1** Filled-out example of the Self-Evaluation Tool (front side)

backside of the form (not shown here) is used to collect additional qualitative data, such as age, date, and the completion of three statements: “I worked at...,” “I am proud of...,” and “This is what I learned...” With the answers on these open questions, we could interpret item B “I learned something” and check whether children meant they learned maker skills (which we expected according to the programs) or other things.

The SET was validated by (i) additional behavioral observations during the making process, (ii) interviews after the completion of the SET, and (iii) comparison with standard test data provided by schools, including individual results for mathematics and reading comprehension and psycho-social data. Validation and adaptation of the SET took place in five subsequent test rounds (period October 2018 to

January 2019) (van Eijck et al., 2018; Van Eijck et al., 2020). This resulted in the SET as shown in Fig. 1.

Interviews with Makerspace Coaches About Learning of the Children The makerspace coaches ($n = 6$) were interviewed. Focus of the interview was the learning of children mainly during the after-school programs, since at that time, the school programs were still in an initial stage. The interviews were conducted in a structured manner using a guideline (Appendix 1).

Interviews with Makerspace Coaches About Their Own Learning The makerspace coaches ($n = 11$) were interviewed about their own learning and training. The guideline for these semi-structured interviews consisted of nine topics and 31 subtopics (Appendix 2), addressing the competences they developed, the strategies they used to guide the children, the difficulties they had to overcome, their beliefs in maker education, their learning experiences, etc. The answers relevant to answering research question RQ3 and RQ4 were selected for analysis.

Interviews with Children Children ($n = 27$) were interviewed for stories that could illustrate the SET-data. The guideline for these semi-structured interviews consisted of five main topics: technology, creativity, collaboration, maker mindset, and experiences with makerspace coaches.

Data Collection

Children filled out the SET in the makerspace during the latest afternoon of a program (using paper-and-pencil). The interviews with makerspace coaches took place on the same afternoon that the children filled out the SET. These interviews lasted about 30 min per person. The interviews with children took place in the makerspace or online, due to the Covid-19 restrictions. These interviews lasted 60 min per person. Audio recordings and notes (partial transcriptions) were made during the interviews. Based on the notes and the recording, transcripts were made of each interview.

Data Analysis

The quantitative data for RQ1 were analyzed with descriptive statistics, and a one-way ANOVA with Tukey post hoc test was conducted to compare the scores on the items of the SET. RQ2 was answered by a qualitative analysis of the transcript with open coding. The utterances were labeled for a descriptive analysis of learning in the categories creating, collaboration, and maker mindset. Typical statements were selected. Finally, RQ3 and RQ4 were answered with qualitative analysis in MAXQDA. From the transcripts of the interviews, the episodes related to the following topics were selected: “competencies of makerspace coaches,” “professional development,” “pedagogy of the makerspace,” and “makerspace in the organization of the

Fig. 2 Mean self-evaluation scores and standard deviations of the items of the SET. A: I invented something new; B: I learned something; C: I helped others; D: Other children helped me; E: I show what I make; F: I like it; G: I persist; H: I dare to

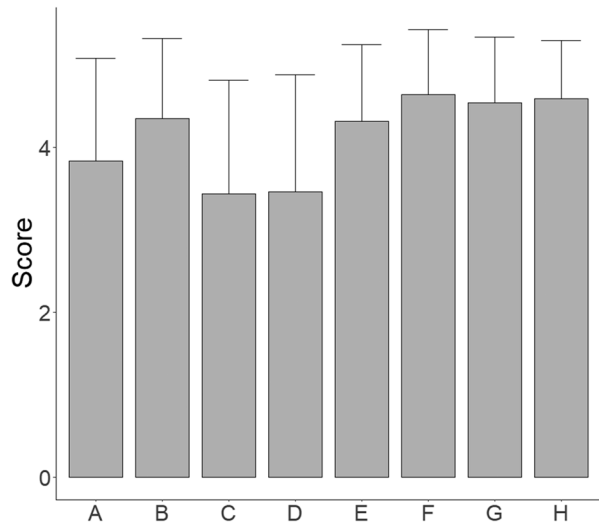


Table 3 Mean scores and standard deviations on the items of the SET

	Creating		Collaboration			Maker mindset		
	A	B	C	D	E	F	G	H
<i>n</i>	304	303	298	300	300	301	304	303
Mean	3.83	4.35	3.43	3.46	4.31	4.63	4.54	4.59
Standard deviation	1.25	0.96	1.38	1.42	0.93	0.79	0.80	0.71

library.” Then within each topic, relevant statements were labeled and axially coded. The findings were summarized.

Results

RQ1. Figure 2 shows how children evaluate their activities and experiences in the SET. The mean scores for each category (items A–H) are shown in Table 3.

Mean scores of children’s self-evaluated learning in the eight categories were compared. All mean scores are above average (3- on a 5-point scale). The within group differences between the categories are shown in Table 4. Children experience less that they help another child (C), or that another child is helping them (D), compared to that they invent something new (A), learn (B), are motivated (F), feel persistent (G), or feel confident (H). The score on category A (I invented something new) is higher than the scores on category C and D but lower than the scores on B, E, F, G, and H.

Answers on the open question of the SET “What did you learn?” showed the following. Most of the children (75%) mentioned some maker skills: tools or software.

After-school	A	B	C	D	E	F	G	H
A								
B	.52***							
C	-.39***	-.92***						
D	-.37***	-.89***	.03					
E	.48***	-.04	.88***	.85***				
F	.80***	.28*	1.20***	1.17***	.32**			
G	.71***	.19	1.11***	1.08***	.23	-.10		
H	.76***	.24	1.15***	1.13***	.27*	-.05	.05	

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Table 5 Experiences mentioned by children in the makerspace during interviews ($n = 27$)

	Number of children that mentioned this theme
In the makerspace you create, you work with tools, materials.	14
At school you learn which means language, maths (as opposed to making)	12
The school is boring whereas the makerspace is fun.	8
In the makerspace you have autonomy, you are free to do what you want	7
In the makerspace you work with technology	6
In the makerspace I collaborate with peers	1

Table 6 Children’s learning in the after-school programs according to makerspace coaches

	C. I	C. II	C. III	C. IV	C. V	C. VI
Maker skills	+	+	+	+	+	+
Creativity	+	+	+	+	+	+
Collaboration	+	+/-	-	+/-	+	+/-
Intrinsic motivation	+	+	+	+	+	+
Persistence and confidence	+	+	+	+	+	+

confidence). Concerning collaboration, there were differences between coaches. Table 7 shows quotations from makerspace coaches about children’s learning.

According to the makerspace coaches, the children learn a lot in the field of technology. Time is spent to learn digital fabrication, but also analog techniques such as tying knots, sewing, or braiding. The longer the children attend programs, the more they learn. Makerspace coaches report that they play games and do exercises to generate ideas and train the children in the iterative design process, and in divergent and convergent thinking.

The experiences with collaboration are more diverse. Children sometimes help each other, but this is not promoted by all makerspace coaches in the same manner. Some makerspace coaches indicate that they value cooperation and that they emphasize this to children or set it as a *social norm* (cf. coach nr. I). In one of the makerspaces, helping each other became a necessity, which arose because the coaches themselves did not have enough time to help all the children. Other coaches indicate that they do not want to enforce collaboration between children and that since the children work on individual projects, helping hardly occurs.

The makerspace coaches unanimously state that children are highly motivated to create and to make. Children enjoy coming to the makerspace, and they keep coming. In fact, there was a waiting list for some of the programs. Children develop persistence and confidence by coming to the makerspace. In all interviews, examples are given of children who are initially reluctant or anxious to express their ideas or to show their work, but they develop as they go along. Another frequently mentioned phenomenon in making is frustration and dealing

Table 7 Selection of quotations of makerspace coaches ($n = 6$) on the activities and experiences of children

Quotation	Result
Creating: Maker skills	
<i>Certainly, the children who have been coming for a while, pick up a new program very quickly. For example, they know Tinkercad and now they work with the online modeling program Sculpt. New children find it more difficult. You see a development in skills in general. (C.VI)</i>	Children develop digital skills, by working with familiar and unfamiliar software.
<i>In principle, we let them work independently, we explain what needs to be done, and most of the children are working on a laptop themselves. Today, the three of us were busy with the Inkscape-questions because it is all new to them. Drawing in such a program is not something you learn in a minute. So we help them, but with the idea of making them work independently. (C. III)</i>	Children learn independently with scaffolding from makerspace coaches.
<i>We had to convert files to be cut with the laser and transform the lines. One of the children can largely do that himself (...) He is the youngest in age, but he can do it all. He comes up with smart solutions. (C. III)</i>	Children are challenged to develop their talents with new technology.
Creating: Creativity	
<i>The idea of making scarecrows came from the children. We thought of a bird feeder. You also ask them to "think along" and we will go along with it. (C.VI)</i>	Children involved in the design-decisions of activities.
<i>For children it turns out to be difficult to be creative when there are too many possibilities. Children can make whole fantasy stories, but they need a theme, constraints in which to work. (C. I)</i>	Children's creativity is challenged with design tasks.
Collaboration	
<i>Every first lesson of an activity we explain the three rules: work together, have respect and don't run. Collaboration is very important to me. (C. I)</i>	Setting norms for collaboration at the beginning of an activity.
<i>They do not work on group assignments. If they have to, they can work together very well, no discussion. But because it is almost unnecessary, it almost never happens. (C.III)</i>	Children hardly work together, since the assignments do not require this.
<i>Helping and being helped is not common, it is not necessary. It is often the children who are already good at it who want to help others. (C. II)</i>	Children that mastered a certain skill want to help other children.
Maker Mindset: Intrinsic motivation	
<i>They have fun; I think that is very important, pleasure in learning. (C. I)</i>	Children have fun in the makerspace.
<i>Seven children have been coming for a long period of time; they come for the full two years, since we started. (C. II)</i>	Children are motivated to come to the makerspace over a longer period.

Table 7 (continued)

Quotation	Result
<i>Children are proud. "Can we take it home?" is a common question. (C. VI)</i>	Children enjoy what they have made.
Maker Mindset: Persistence and confidence	
<i>Mother has said that she is a girl who is often shy and on her own, but by coming here she starts to blossom, she starts to dare more, her mother says. We also see that in the program. There are still things that I think she could dare to do more. She has grown a lot. (C. I)</i>	Children develop confidence in the makerspace.
<i>Last week coincidentally, a girl really had a fight with her project. She wanted to give up and said "I don't need to have such a purse anymore". I told her she was free to go home if she really wanted. But she stayed and she persisted. (C. II)</i>	Children learn to persist and deal with frustration in their maker projects.
<i>Seven kids have been coming for the full two years. Nice to see what they make and how they have changed personally. One of them, in the beginning, when something did not work, she started immediately started to cry, that's over now. Another kid who recently turned 8 years old too, at first he was very quiet, now he talks more. (C. II)</i>	Children develop confidence in the makerspace.

with it. Children overcome personal bumps, and the coaches help them with that. The longer children are in the makerspace, the more confidence they show.

RQ4. Which competencies and skills did makerspace coaches have to master, according to themselves? Table 8 shows for each of these competencies whether makerspace coaches mentioned this during their interview.

Expert in Technology and Creativity All makerspace coaches had to acquire digital skills and to learn to work with the design software and the machines for digital fabrication. For those who were completely new, this took months: Coaches with a creative background learned this faster, in weeks. All makerspace coaches mentioned

Table 8 Acquired competencies mentioned by makerspace coaches

	Coach started in 2017 (n = 3)	Coach started in 2018 (n = 4)	Coach started in 2019 (n = 4)	TOTAL (n = 11)
Expert technology and creativity	3	4	4	11
Supervisor of children's activities	3	4	4	11
Designer of new activities	3	1	4	8
Coordinator in the makerspace	2	3	2	7
Evaluator of projects	1	1	1	3

that they kept on developing their technological competence, both by deepening and extending their knowledge of software, techniques, and tools.

Supervisor of Children's Activities Guiding activities with children was extensively mentioned by all coaches as an important learning goal when they started as a coach, and still. This pedagogical-didactic competence includes:

- Building a personal bond with the children, feeling what children need, reassuring, and challenging them. Several coaches referred to giving that individual attention as an essential part of their work.
- Teaching and presenting for a group of children. This includes explaining the activities, the tools, the machines, and encouraging the children. Some coaches had experience in addressing groups, for others it was completely new.
- Running a program with the children, knowing which activities are suitable for a certain target group and being able to adapt. Several coaches mentioned that they initially tended to overload the program and that they wanted to do too much in one afternoon. Gradually they learned to ensure that activities matched the children's prior knowledge and to take time to learn certain skills. Some coaches learned to let go and improvise (instead of always preparing all activities in detail), while others discovered that preparing the activity and technology was important.
- Guiding inquiry and design learning, while safeguarding the balance between offering structure and help on the one hand and offering space and challenge on the other. Makerspace coaches indicated that they have learned that providing a framework and setting constraints are important for stimulating creativity.
- Dealing with undesirable behavior is something all coaches must address sooner or later. Many coaches indicated that they had learned to handle this, prevent it where possible and thus create a safe climate in the makerspace.

Designer of New Activities Designing new programs was not mentioned as a challenge by all makerspace coaches. Not all makerspace coaches were involved in the development of new programs. Makerspace coaches who developed new activities emphasized that they (could) use their personal preferences and expertise. They also mentioned that this required time. Some makerspace coaches indicated that during a special program in summer holiday (when children came to the makerspace every morning during one week), they had time to experiment with new activities.

Coordinator in the Makerspace Various makerspace coaches mentioned aspects of being the coordinator in the makerspace. The management of the machines played a major role in this, together with the resolution of minor technical problems and the responsibility for materials and tools. Collaboration with colleagues also played a major role in "running" a makerspace independently. Makerspace coaches stated that the complexity of the job required that as a team of makerspace coaches you could rely on each other and that you are able to give and receive feedback. The coordinating role as makerspace coach also includes planning and organization: on the one

hand being responsible for organizing one’s own time in preparing the activities, on the other hand being able to follow the tight schedule of the library-timetable.

Evaluator of Children’s Learning Evaluating the learning of children and documenting programs was hardly mentioned by coaches as something they had to learn. They were hardly addressed to evaluating children’s work.

RQ5. How did makerspace coaches acquire the required competencies and skills? Which learning activities contributed to their professional development? Table 9 shows that coaches indicated that the meetings with other coaches gave them a solid foundation, especially the “Librarian Maker Camp.” At the same time, they indicated that “real” learning took place in practice. The first batch of makerspace coaches (start 2017) had to figure out a lot by themselves. They state that mastering digital skills and working with the machines took days or more and that they were given the space to work on it in that way. The third group of makerspace coaches (start 2019) needed less time to learn the digital skills and could rely on their colleagues in the makerspace for guiding the activities. Coaches unanimously state that they learned a lot — and are still learning — from colleagues. Especially the second and the third groups of coaches got guidance in the activities from experienced colleagues and learned a lot from that.

Conclusions

A library makerspace offers children opportunities to learn. What children learn is shaped by the activities and by the guidance of makerspace coaches.

RQ1. Children report that they learn about digital technology and that they are creative in the makerspace. They mention that they are very motivated and experience confidence in the makerspace. To a lesser extent, they report that they help each other.

RQ2. Makerspace coaches confirm the children’s reports. They narrate that children adopt maker skills, develop their creativity, love to come to the makerspace, and develop confidence. Their estimation of children helping each other are in line with the experiences of children.

RQ3. Makerspace coaches mention that first of all, they had to develop as a maker themselves and master the software and hardware for design and

Table 9 Important learning activities mentioned by makerspace coaches

	Coach started in 2017 (n = 3)	Coach started in 2018 (n = 4)	Coach started in 2019 (n = 4)	TOTAL (n = 11)
Training meetings	3	3	2	8
Self-employed learning	3	3	1	7
Learning with and from colleagues	3	3	4	10

production (*technology and creativity*). Subsequently, they put a lot of effort in learning how to assist and challenge children becoming makers (*pedagogical content knowledge*). Makerspace coaches had to learn how to handle groups of children (*pedagogy*) and do design learning activities (*educational design*). Finally, they had to set up their makerspace (*organization and management*). The evaluation of children's activity was hardly mentioned by the makerspace coaches.

RQ4. The many facets of this new (librarian's) profession are best learned and trained in a professional learning community. Such a community must be adaptive, responsive, and in line with the coaches' prior knowledge. It facilitates input from experts from different disciplines as a source of inspiration, and enables learning by doing in practice, and learning from and with colleagues. Finally, this professional learning community is evidence-informed and supports reflection on action.

Discussion

In the city of Amsterdam, public library makerspaces offer many opportunities for children to play, grow, and learn and hence succeed in their goal to provide learning opportunities for all children. The activities of the children were measured with various instruments, including the SET (Self-Evaluation Tool). This instrument contained one item per category, which may have limited the obtained data.

The training of coaches reflects into the learning of the children. Makerspace coaches function as role models and personal mentors for the children. The findings on "collaboration" are mixed: on the one hand, some coaches mention that children help each other often and that they share their work; on the other hand, coaches do not want to enforce this. In after-school settings, children may exchange their ideas "through the air" and cooperate by "sitting aside" (Halverson et al., 2018; Kumar et al., 2020). The notion of collaboration in a makerspace can be extended and reinforced, both in this project (professional development) as in future research.

Evaluation of children's activities may become important for makerspace coaches in the future, especially when the collaboration with schools grows. The SET provides opportunities to collect children's experiences and to reflect on them, thus stimulating peer- and self-assessment of activities by children.

Makerspace coaches mention that they want to stimulate autonomous learning, but at the same time, "the many factors that put extra pressures on children and staff (...) can make it difficult to maintain these distinguishing features. Staff may fall back on school-like practices of behavior regulation that constrain the ability to design for freedom and belonging." (Escudé et al., 2020, p. 43). This underlines the importance of continuous professional development of makerspace coaches.

The public library makerspaces succeed in reaching out to children who do not have access to resources at home. This informal learning environment positively influences children's development. In the coming years, the relationship with formal learning in schools will need to be further explored.

Appendix 1

Interview guide for makerspace coaches “Children’s learning in the public library makerspace” (translated from Dutch)

1. What is the name of the program?
2. Which tools and materials do children use in this program? (maker skills)
3. Who are the makerspace coaches?
4. Which children are coming to the makerspace for a longer time?
5. What did the children learn on creativity?
6. What did the children learn in the field of giving and receiving help?
7. How do the children develop as a person in the makerspace?

Appendix 2

Interview guide for makerspace coaches “Makerspace coaches’ learning in the public library makerspace” (translated from Dutch)

1. Personal data
 - a. What is your name?
 - b. What is your age?
 - c. Professional background
 - d. What is the size of the appointment at the library makerspace?
 - e. Do you also work on another department in the library?
 - f. When did you start as a makerspace coach?
 - g. Which makerspace do you work?
 - h. Do you have a fixed colleague in the library makerspace
 - i. What was your motivation to become a makerspace coach?
 - j. What do you prefer to make by yourself? (materials, tools, ...)
2. Competences and skills of makerspace coaches
 - a. What did you have to learn and to master when you became a makerspace coach?
 - b. What was the biggest challenge you were confronted with as a makerspace coach?
 - c. Did you even have the feeling that you had to do something you were not trained to do?
 - d. What is easy for you as a makerspace coach?
 - e. What are skills you had to develop as a makerspace coach?
3. Professional development
 - a. How did your education as a makerspace coach look like?

- b. How did the training contribute to what you can do now as a makerspace coach?
 - c. What did you miss in your training as a makerspace coach?
 - d. How do you keep developing as a makerspace coach?
 - e. How did colleagues contribute to your development as a makerspace coach?
 - f. How do you develop new programs for the children?
 - g. How do you collaborate with colleague-makerspace coaches?
 - h. What do you need to keep developing as a makerspace coach?
4. Domains of learning of children in a library makerspace
 - a. What do you think to be the most important learning goals for children in a library makerspace?
 - b. Do you look at it the same as when you started?
 - c. Can you describe a child in the makerspace who has gone through great development?
5. Pedagogy in the library makerspace
 - a. What are your strategies to guide children in the makerspace? Do you work with *instructables*? Trial-and-error?
 - b. What pedagogical strategy is difficult for you to master?
 - c. Do you stimulate collaboration between children?
 - d. Do children help each other?
6. Collaboration of the library makerspace with the neighborhood
 - a. Do you have contact with parents? Do they tell you about what the children report on their experiences in the makerspace?
 - b. One of the goals of the library makerspace was to stimulate neighborhood development. How does that work out?
 - c. How is the collaboration with the neighborhood?
7. Collaboration of the library makerspace with schools
 - a. What is the difference between learning in the makerspace and learning at school?
 - b. What are your experiences in the collaboration with schools?
8. Organization of the makerspace in the public library
 - a. The makerspace is part of the organization of the public library. What do you notice?
 - b. Do you feel supported by the organization as a makerspace coach?
9. Future of the library makerspace
 - a. How do you think of your future as a makerspace coach?

- b. What are your concerns for the future as a makerspace coach?
- c. What are your wishes?

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Declarations

Reasoning for Publication Maker education is finding its way to the school curriculum, and there is a growing interest in informal STEM-learning. The findings presented in this contribution are interesting for educators and researchers in the field of STEM education, who want to implement maker education in their practice, both in and outside school. In particular, the study provides a self-evaluation-tool to assess children's experiences in a makerspace.

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