Social Competence and STEM: Teen Mentors in a Makerspace

David Bar-El
Media Innovation Lab
School of Communications
IDC Herzliya, Israel
david.barel@post.idc.ac.il

Oren Zuckerman
Media Innovation Lab
School of Communications
IDC Herzliya, Israel
orenz@idc.ac.il

Yaron Shlomi
Media Innovation Lab
School of Communications
IDC Herzliya, Israel
yaron.shlomi@idc.ac.il

IDC '16, June 21-24, 2016, Manchester, United Kingdom
ACM 978-1-4503-4313-8/16/06.
http://dx.doi.org/10.1145/2930674.2936005

ABSTRACT
We study the experiences of high school student volunteers as mentors in a public makerspace for children. Based on interviews, we present the teenagers' varied backgrounds, doubts, and lessons learned. While most studies around maker activities have focused on learning of STEM subject matter, our findings point to an additional outcome, an empowerment in social competence. We discuss our insights about teenage mentorship in makerspaces and propose future research directions.

Author Keywords
Makerspace; Digital Fabrication; Peer Learning; Informal Learning; Collaborative Learning;

ACM Classification Keywords
K.3.1 [Computers and Education]: Computer Uses in Education – Collaborative learning

1. INTRODUCTION
Making has received robust attention from researchers in the last few years as a promising educational practice [11]. This scholarship has focused on several aspects: novel toolkits [6], curricula design [12] and understanding what learning in making looks like [4].

Mentor Training

Eight sessions were run by undergrad students who supervise the Maketec. Seven hands-on workshops on the makerspaces' technology and one session about the mentor's role.

The training's purpose was twofold; A. to provide an understanding of the tools; and B. to allow the teenagers to be mentored themselves.

Figure 1. (Top) A mentor learning how to use the 3D printer. (Bottom) A training session about the meaning of mentorship and scaffolding in makerspaces.

Making is seen as a hands-on activity associated with several learning-related benefits [15]. These include: democratizing the use of digital tools [5], gaining 21st century skills such as "*Computational thinking"* [14], and introducing otherwise disengaged youth to STEM subject matter [7, 12].

In this paper we introduce social competence as another possible benefit of youth engagement in making activities. Studies of peer-assisted learning (PAL) suggest that PAL interventions yield gains in social skills and self-esteem [8]. PAL includes modes of interaction between learners that can be found in many maker activities. These include collaborative learning, private tutoring and group tutoring. We believe that as makerspaces and making activities become more prevalent, social competence should be included as an integral goal of such educational practices.

2. RELATED WORK

As stated above, PAL is in some cases an inherent aspect of making activities for children. If adults facilitate the activities, children may assist each other in the process. If allowed to do so, children may serve as facilitators themselves. In sum, as children work on maker projects, it is common that knowledge is distributed in such a way that affords collaboration and in some cases tutoring.

One example of PAL under adult instruction is found in FUSE studios around the United States [10]. FUSE studios are led by adult educators and are comprised of challenge sequences that become increasingly difficult like in video games. The challenges require the use of different technologies such as 3D printers, e-Textiles, and app design software. Researchers of the project observed that the shared work spaces allowed children of different expertise levels to provide ideas, hints and help others to complete challenges.

A second example, which represents PAL under children's instruction is found at the Lamar school makerspace in Flower Mound, Texas [9]. This makerspace is run by a school librarian and offers two modes of activity. The first is free experimentation with digital physical toolkits, and the second is structured student-run workshops in various subjects such as blogging and web-design.

3. MAKERSPACE CONTEXT

This study is focused on the Maketec, a drop-in makerspace situated in a public library in Tel-Aviv, Israel. Children (age 9-14) from the makerspace's surrounding neighborhoods visit and engage in digital fabrication (3D printers), digital prototyping (e.g. Little Bits [2], paper-circuits [16], and coding (Scratch) [13]. To scaffold the creative and learning processes, teenage mentors are constantly present. In addition, printed project instructions are available for inspiration or guidance.

Mentors in the makerspace volunteer in order to complete sixty hours of community work, as required of all high school students in Israel. Mentors were trained in eight sessions (see Figure 1 for an illustration of the training). These consisted of seven project based introductions to the makerspace's technologies and one session on the role of the mentor. In this last session, it was explained to the teenagers that their responsibility was not to teach, but rather to support children's intrinsic motivation to create, and offer assistance when the kids encounter hurdles in the making process.

Other than participation in these sessions, there were no other criteria for admission.

4. STUDY

Previous research examined the experiences of the Maketec's visitors [1]. In this study we focused on the teenage mentors. We wished to see if the mentors' voluntary work served as an empowering experience for them. We present the mentors' attitudes at the beginning of their tenure in the makerspace, and follow up with their reflections on the experiences they had throughout the shifts.

4.1 Method

Participants

Participants were 6 female and 10 male students (age M = 15.42, SD = .51) from three different high schools. They completed a minimum of 40 hours in the makerspace at the time the study took place (see Figure 2 for mentoring illustration).

Procedure

One of the researchers conducted semi-structured interviews with the mentors, who had not met him before. Interviews were held face-to-face, outside the makerspace and lasted 20-30 minutes. Mentors were told that the interviews would be recorded for research purposes only. The recordings were transcribed by one of the researchers. The research team then compared the transcripts and extracted common themes and related quotes. Quotes were translated from Hebrew to English and participant names were anonymized.

4.2 Pre-Mentorship

4.2.1 Backgrounds

We propose that the mentors' backgrounds contain two strands of experiences relevant to their mentoring: experience with children and experience with STEM. Most mentors (11/16) had prior STEM experience: four were gifted students who had already started studying towards a bachelor's degree in computer science or math, five were science majors in high school, and two learned programming and felt comfortable with technology. Half (8/16) of the mentors stated to have previously worked with children: five had experience as babysitters, tutors, or instructors in school or youth movement activities, and three stated that having younger siblings had prepared them for working with children.

4.2.2 Doubts

The mentors were asked about any doubts they had before starting to work in the makerspace. The most common doubt was "I wouldn't know how to instruct the kids". Shared by 7 mentors, this doubt can be broken down into two separate feelings reflected in the following quotes; (1) "I wouldn't know how to explain things", and (2) "how do I mentor without telling them what to do?" Based on follow up questions and answers in the transcripts, the first feeling seemed to either reflect a general anxiety associated with the responsibility of instructing children, or doubts about their knowledge of the technologies. The second feeling seemed to be the consequence of the last training session, in which the role of mentor as "not a teacher" was discussed (see Section 3).

Mentoring

The mentors devote a weekly two-hour shift in the makerspace.

Each shift has two to three mentors, and up to eight younger visitors.

Figure 2 (Top) mentors operate the 3D printers and assist freely working children when needed. (Bottom) a mentor guiding four children through a Makey Makey [3] project.

Another doubt was “not being able to cope with the children”, shared by 6 mentors. This doubt seems to reflect two distinct concerns: (1) “I won’t be able to control the kids” and (2) “I won’t be able to regulate myself in light of stress and difficult children”. Five of the six mentors sharing this set of doubts had no experience with children when they started their Makerspace work. The sixth stated that her experience was having a younger sister. Importantly, none of the mentors who had worked as babysitters, tutors or instructors shared these doubts.

4.3 During Mentorship

The mentors were asked if their experience helped them learn anything that significantly changed their views on technology, children, or themselves. Analyzing the answers to this question, we present common themes from our interview data and focus on specific case studies that best exemplify different outcomes.

Outcome 1: No Empowerment

Three mentors stated that their experience didn’t empower them with regards to technology, children or themselves. Two of them said they had no doubts regarding instructing children before volunteering and felt no change in their attitude towards technology either. The third mentor, Joey, felt that his experience was actually a negative one.

Joey is a 15 year old boy. He volunteered because his friends told him about the makerspace and he found 3D printing to be appealing. Before volunteering, he had no experience with STEM or children. He feared he wouldn’t be able to deal with problematic visitors. Reflecting on his shift, he said that on some days it’s ok but many times he gets really angry and yells at the children. When asked what he learned he said “*I learned that kids can be nasty, hyperactive, creative, and dependent. I don't like the responsibility”.*

Outcome 2: STEM Empowerment

Nine mentors stated that they had learned things about technology and its use. Five of the nine talked about 3D printers, their surprising ease-of-use, and their future potential uses. Four talked about feeling generally more competent with technology.

Nina is a 16-year-old girl who doesn’t have a STEM background. She had previous experience instructing younger students at school, and volunteered because she loves books and wanted to work in the library with children. Her doubts were *“Not being able to control the kids or to operate the technologies”*. When asked what she thought about technology after being a mentor she said “*I used to think that I couldn’t understand anything. Now I understand everything that’s needed here in the makerspace.”*

Outcome 3: Social Empowerment

Ten mentors said that they had learned meaningful things about children or themselves. Regarding children, mentors talked about different ways to motivate, instruct and deal with them. About themselves, mentors talked of self-regulation, being more responsible in their personal life, being assertive while being compassionate, and being able to teach.

Ben is 15 years old, a gifted high-school student who studies computer science (at undergrad level). He had no experience with children prior to being a mentor in the makerspace. When asked about his doubts, Ben said *“I feared that I wouldn't be able to instruct at all”*.

When asked if he had learned anything about children or himself he said *"Yes, that I am capable of teaching. It was a great challenge and I decided to take it on".*

Talia, 16 years old, chose science (physics, chemistry, and biology) as her focus in high school. She too had no experience with children. She had doubts about *"Getting along with the kids, I've never been responsible for kids".* When asked about learning new things she said *"I like working with the children, it's hard sometimes if one of them is rude to us mentors, but I learned that there are different ways to approach them".*

Outcomes summary

Informed by the three outcomes, we lend our insights about teen mentorship in makerspaces. The No Empowerment outcome suggests that not everyone can gain from makerspace mentorship. For example, Joey who was one of two mentors in our sample who had no experience before volunteering. Thus, selection of future mentors should be guided by the teenager's prior experience (or lack thereof) in STEM or working with children. The STEM Empowerment aligns with most of the research around making outcomes: the mentors felt more confident about their abilities with technology and learned about the different tools used in the space. We believe that the Social Empowerment outcome is most promising. As is best exhibited in Ben and Talia's cases. Students who are engaged in STEM may also gain lessons in social skills through makerspace mentorship.

5. CONCLUSION AND FUTURE WORK

This paper explored the experiences of high school students as they mentored kids in a drop-in makerspace. Based on interviews with 16 teenagers who spent 40-60 hours as mentors in the makerspace, we present some of the lessons learned related to technological and social competence. We found that mentors started their volunteer work with different levels of experience in both domains, and had different doubts toward their work. Our results indicate that for most mentors (13 of 16), the mentoring experience empowered technological competency, social competency, or both.

Limitations of our work are the small sample size, and the indirect measurement of the mentors' knowledge and skills, pertinent to technology and social competencies. Future research should use standardized instruments and a pre-post design to quantitatively examine the outcomes of teenage mentorship in makerspaces.

We believe that the popularity of makerspaces as educational settings holds great potential for youth empowerment. A growing body of research has supported the promise of making as a means to empower learners with regards to STEM fields. We hope our work inspires future research on PAL in making activities and its outcomes on social competence.

SELECTION AND PARTICIPATION OF CHILDREN

In this study 10 children aged 15 -16, from three schools in a major city in Israel were recruited. Prior to the study University ethical approval was obtained. Selection was by virtue of participants volunteering as mentors in the Maketec. Participants and their parents provided informed consent for participation in the study and the inclusion of photographs. It was explained to both parties that data would be used for research purposes only, and that anonymity will be kept.

Acknowledgements

We want to thank Rona Sadan, Daphna Sapir and Noa Morag for managing the Maketec; the teenage mentors for their participation; and the Sara Fine family for their generous support of the Maketec project.

References

[1] David Bar-El, and Oren Zuckerman. 2016, February. Maketec: A Makerspace as a Third Place for Children. In *Proceedings of the Tenth International Conference on Tangible, Embedded, and Embodied Interaction* (TEI '16) 380-385.

[2] Ayah Bdeir. 2009. Electronics as material: littleBits. In Proceedings of the *3rd International Conference on Tangible and Embedded Interaction* (TEI '09) 397-400.

[3] Beginner's Mind Collective, and David Shaw. 2012. Makey Makey: improvising tangible and nature-based user interfaces. In Proceedings of the sixth international conference on tangible, embedded and embodied interaction (TEI '12) 367-370.

[4] Bronwyn Bevan, Joshua Gutwill, Mike Petrich, and Karen Wilkinson. 2014. Learning through STEM-rich tinkering: Findings from a jointly negotiated research project taken up in practice. *Science Education*.

[5] Paulo Blikstein. 2013. Digital fabrication and 'making'in education: The democratization of invention. *FabLabs: Of machines, makers and inventors*, 1-21.

[6] Paulo Blikstein. 2013, June. Gears of our childhood: constructionist toolkits, robotics, and physical computing, past and future*. In Proceedings of the 12th International Conference on Interaction Design and Children* (IDC '13) 173-182.

[7] Nomusa Dlodlo and Noel Beyers. N. 2009. Experiences of South African high school girls in a fab lab environment.

[8] Marika D. Ginsburg-Block, Cynthia A. Rohrbeck, and John W. Fantuzzo. 2006. A meta-analytic review of social, self-concept, and behavioral outcomes of peer-assisted learning. *Journal of Educational Psychology*, *98*(4), 732.

[9] Colleen Graves. 2014. Teen Experts Guide Makerspace Makeover. *Knowledge Quest*, 42, 8-13.

[10] Kemi Jona, Lauren Penney, and Reed Stevens. 2015. 'Re-mediating' Learning. *In Proceedings of the Eleventh Conference on Computer Supported Collaborative Learning* (CSCL '15). 348-355

[11] Lee Martin. 2015. The promise of the Maker Movement for education. *Journal of Pre-College Engineering Education Research* (J-PEER), 5(1), 4.

[12] Kanjun Qiu, Leah Buechley, Edward Baafi, and Wendy Dubow. 2013, June. A curriculum for teaching computer science through computational textiles. In *Proceedings of the 12th International Conference on Interaction Design and Children* (IDC '12) 20-27.

[13] Mitchel Resnick, John Maloney, Andres Monroy-Hernández, Natalie Rusk,Evelyn Eastmond, Karen Brennan, Amon Millner, Eric Rosenbaum, Jay Silver, Brian Silverman, and Yasmin Kafai. 2009. Scratch: programming for all. Communications of the ACM, 52, 60-67.

[14] Mitchel Resnick, and Brian Silverman. 2005. Some reflections on designing construction kits for kids. *Proceedings of Interaction Design and Children Conference*, Boulder, CO.

[15] Shirin Vossoughi, and Bronwyn Bevan. 2014. Making and tinkering: A review of the literature. *National Research Council Committee on Out of School Time STEM*. Washington, DC: National Research Council, 1-55.

[16] http://chibitronics.com/