Let Me Hack It: Teachers' Perceptions About 'Making' in Education

Ville Heilala[1], Mirka Saarela[1], Sanna Reponen[2], and Tommi Kärkkäinen[1]

[1] University of Jyväskylä
ville.s.heilala@jyu.fi
[2] Mehackit.org

Abstract. *Making* in education is an emergent practice focusing on learners as creators of things in a collaborative fashion while promoting knowledge construction through technology, design, and creative self-expression. Teachers' ($n = 33$) opinions about making were studied using an online questionnaire after they had attended an online course for professional development about making in education. The results suggest that there exists a group of educators who consider making as a promising approach in education and want to promote its use in schools.

Keywords: making in education, maker movement, digital humanities, student agency

1 Introduction

Learning digital skills and competencies is essential. It is an endless life-long learning journey which also forces us, educators, to reflect on our ways of teaching and reform our pedagogical practices. In addition to educators, the digital world also offers endless opportunities for all other representatives of the humanities. The ubiquitous digital world has given rise to a multidisciplinary approach called digital humanism, which is an area of research that unites computing and the traditional arts, social sciences, and humanities. It is defined by the "opportunities and challenges that arise from the conjunction of the term digital with the term humanities" [4, p. 122].

Making as a promising educational approach [1] refers to an educational movement, which is based on learning-by-doing with hands-on activities, creation of prototypes and artifacts, and collaborating in digital fabrication labs as learning environments — makerspaces [2, 10]. Halverson states, that the maker movement "refers broadly to the growing number of people who are engaged in the creative production of artifacts in their daily lives and who find physical and digital forums to share their processes and products with others" [7, p. 496]. The maker movement promotes the digital humanities and actively contributes to it by emphasizing informal learning through creativity, peer-interaction, and digital tools [11, 9].

The theoretical basis of the maker movement is founded on the experiential learning by Dewey, constructionism according to Piaget and Papert, and Freirean

critical pedagogy [2]. Making allows students to acquire technical skills and to construct mental models about troubleshooting and problem decomposition [5], thus, having a close resemblance to the underlying aims of *computational thinking* [15]. In this regard, the *maker mindset* is to be developed through playful experiments in asset- and growth-oriented, failure-positive, and collaborative manner [10]. Clapp et al. suggest, that "the core educational outcomes of maker-centered learning concern the development of agency and character" [6, p. 163].

The research about making has been concentrating on developing STEM learning and enhancing programming skills and computational thinking, while the materials used in making range from latest digital tools and software to more traditional and tangible materials [13]. The recent research has been focusing on learner's point of view, and especially quantitative research from the teacher's perspective has been scarce [13, 1].

The purpose of this paper is to examine Finnish teachers' opinions about making in education after they have attended an online course called *Let Me Hack It* during which they developed their competencies in making — more specifically — creativity, technology, and programming in an educational context. Teachers' competencies relating to the educational use of making were examined through the lens of technological pedagogical content knowledge (TPACK) [8]. Furthermore, teachers' opinions about making in education and the reasons to attend the course are studied.

2 *Let Me Hack It* - Creative technology and coding for teachers

Let Me Hack It was a free-of-charge 7-week online professional development training funded by the Finnish National Agency for Education. The course was organized by Mehackit, a social enterprise which focuses on giving both live and online coding courses and teacher training workshops since 2014. *Let Me Hack It* was designed to encourage primary and secondary school teachers in Finland to view and teach programming as a creative practice. The creative approach aims to make ICT more appealing and personal to a variety of students regardless of their background and skill level. From the teachers' professional development point of view, the aim was to contribute to teachers understanding about the interaction of pedagogy, technology, and content.

The participants completed a track of programming exercises related to music, visual arts, or creative electronics (Fig. 3). A major part of the course consisted of getting acquainted with maker culture and the different aspects of the creative work process. The educational and applied approach was important; teachers' were encouraged to deal with the lessons learned in relation to their teaching practice and subject matter expertise. No prior experience in programming was required. Open-source culture and resources were introduced along the way. The programming tools used in the course (Sonic Pi, Processing, and Arduino) are open source technologies, as well as the course platform Open edX. The participants received digital badges for completing the course.

The basic structure of the course was designed around the themes of the underlying learning model (Fig. 1), which is based on creativity research, constructivist learning theory, maker and STEAM (science, technology, engineering, arts, and mathematics) education, and design thinking. The learning model is flexible in order to support creative project work by allowing multiple entry points and diverse working paths.

Fig. 1: Pedagogical model of the *Let Me Hack It* online course.

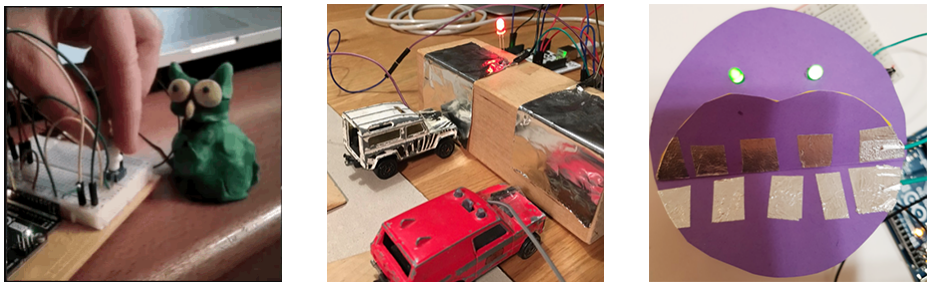

Fig. 3: Three examples of teachers' creations in the *Let Me Hack It* course.

3 Data and Results

Teachers completed an online survey after the course. The survey was sent by email to all teachers who signed up for the course ($N = 399$). A total of 33 complete responses were received. The response rate (RR1) of the survey was

8.3%. The questionnaire consisted of Likert items and open-ended questions. Due to the small sample size, Likert items are analyzed using descriptive statistics. Open-ended answers about the reasons to participate in the course were analyzed by the first author using thematic analysis [3].

The basis for the questionnaire items was the concept of technological pedagogical content knowledge (TPACK), which depicts "an understanding that emerges from interactions among content, pedagogy, and technology knowledge" [8, p. 66]. The Likert items in the survey aim to reflect the respondents' understanding of technology, pedagogy, and contents underlying the educational use of making. The analysis of the questionnaire data seeks to answer the following research questions: Why did the teachers decide to attend the course? (RQ1), How teachers assess their TPACK knowledge relating to making after the course? (RQ2), Do teachers think making is a relevant educational approach? (RQ3), and What kinds of advantages and disadvantages teachers see in using making in teaching and learning? (RQ4).

Most of the respondents (70%) were working in Finnish basic education. Rest of them were working on other school levels, and two respondents were from different fields than education. In general, respondents had already established their careers as educators since 70% of the respondents working as educators had more than five years of teaching experience. 51% of the respondents were women. Respondents represented a wide range of subject areas. However, the main subject areas were mathematics, natural sciences, and craft education. 62% of the respondents completed the course, and the rest completed it partially. Respondents assessed on a 1-10 scale how familiar they were with making at the beginning of the course. In general, the respondents were not very familiar with making before the course ($X_m = 4$, $IQR = 2$) and 20% had used Arduino, and one respondent had used Processing before the course.

3.1 RQ1: Reasons to attend the course

One open-ended question addressed the issue of why the teacher decided to take part in the online course ("Why did you decide to sign up for the online course?"). All of the respondents answered this question. Answers were analyzed thematically, and we identified the following reasons (frequencies in parentheses):

- **interest in subject (14), interesting preconception (6)**: teachers mentioned that they are interested in the subject (e.g., "The subject is interesting"), and they had a positive preconception (e.g., "The course sounded interesting").
- **personal development (5), wanting to learn new (5), lack of previous knowledge (3), employability (1)**: teachers participated for the personal development, they did not have previous knowledge and wanted to learn something new (e.g., "I wanted to learn new skills. Coding was a completely new area for myself").
- **work requirement (5), applicability in practice (3), interest in applying (2)**: teachers had a work-related requirement and they were seeking something they could apply in their own teaching (e.g., "In our school, Processing is used in programming in mathematics", "I wanted something new to teach in class")

– **possibility to receive guidance (2), flexible studying (1), certificate of completion (1)**: for some teachers, the possibility to study online was a reason to participate as the course provided flexible way of studying while providing same time the opportunity to receive guidance. A certificate of completion was mentioned in one response.

In general, teachers signed up for the course because they were interested in and curious about the subject, and they had a positive preconception about making. Some of them participated in for personal development and because they wanted to learn something new. Furthermore, precise work-related requirements and applicability of the learned knowledge and skills were essential factors. Results, as mentioned above, were expected as technology-oriented teachers might more willingly attend courses involving technology.

3.2 RQ2: Teachers' technological pedagogical content knowledge relating to making

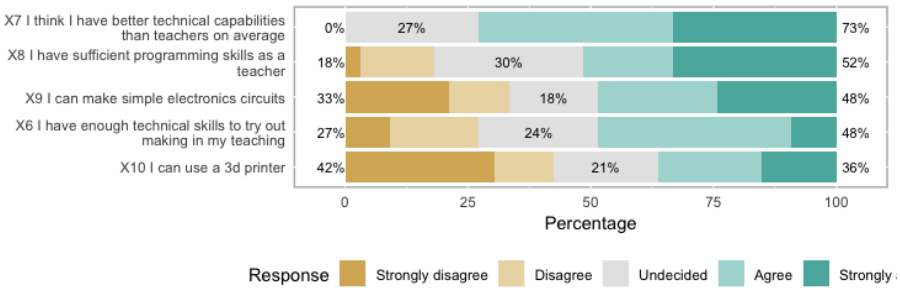

Fig. 4: Items depicting teachers' technical competencies.

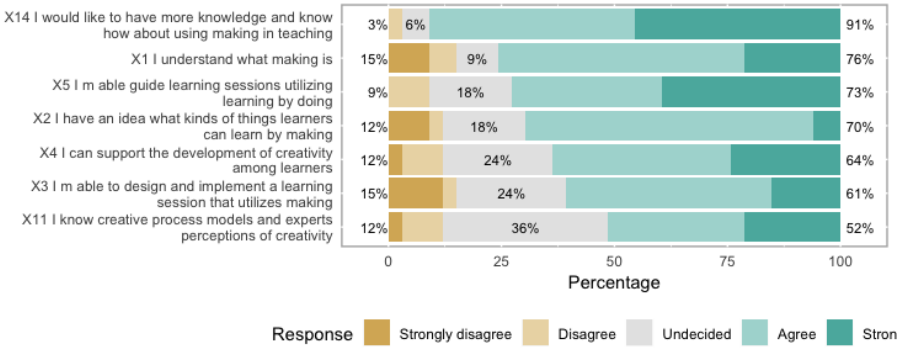

Fig. 5: Items depicting teachers' pedagogical and content related competencies.

Questionnaire items in Fig. 4 depict the teachers' technical competencies relating to making. In general, they were well technology-oriented teachers. Majority of the respondents (73%) assessed their technical capabilities as better than teachers on average, and half of the respondents were confident in trying out implementing making in practice. Furthermore, half of the respondents evaluated their programming skills as sufficient for a teacher (52%), and they could make simple electronic circuits (48%). Both skills, programming, and electronics were core subjects in the online course, and they are valuable for educators utilizing making in the context of teaching and learning. Comparing to previous skills, using a 3d-printer was seen as somewhat more advanced skill as one out of three respondents reported the ability to use one. However, this might also be due to lack of access to a 3d-printer.

Pedagogical items of the questionnaire (Fig. 5) concentrated on teachers' abilities to implement actionable and creative learning sessions. The content in the online course focused on developing insight about creativity and educational background of making. After the course, three out of four respondents had an idea of what making is. A slight majority assessed they could implement actionable making sessions supporting creativity, while others disagreed or were undecided. Most notably, almost all of the respondents would like to have more knowledge and know-how about making, which might indicate a more profound interest and motivation towards making.

3.3 RQ3: Teachers' opinions about making in education

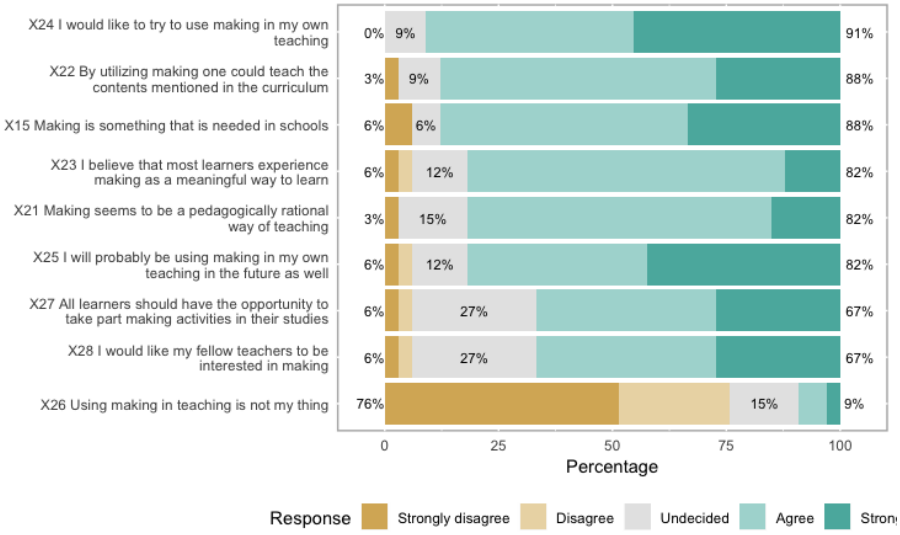

Fig. 6: Items depicting teachers' opinions about making in the context of teaching and learning

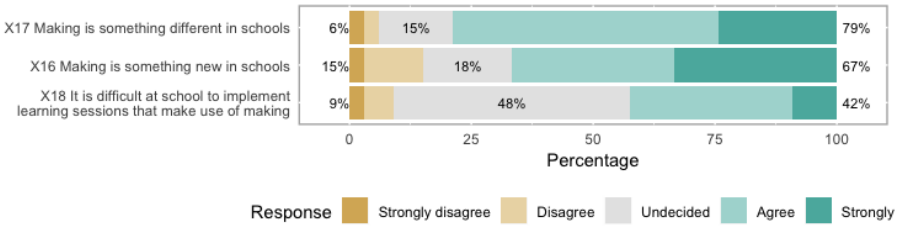

Fig. 7: Items depicting teachers' opinions about the status of making in schools.

Almost all of the respondents wanted to try making in their teaching, and the majority (82%) would probably continue using making as a part of their teaching practices. Furthermore, making was considered something that is needed in schools. Teachers assessed making as a pedagogically meaningful way to teach and learn the contents in the curriculum. Two out of three respondents thought that all learners should have an opportunity for making, and they would like their colleagues to be also interested in making. While the teachers' opinions about making were overall quite positive, one out of four respondents disagreed or were undecided whether making "is their thing".

The teachers who attended the online course were interested, motivated, and they assessed to have better technical skills than average teachers. Notably, while being highly technology-oriented, the respondents still considered making to be something new (67%) and different (79%) in Finnish schools. Furthermore, about half of the respondents assessed making to be difficult to implement in schools.

Table 1: Summary of background variables (gender and age group) for selected items.

		gender		**age group**			
item	answer	male	female	25–34	35–44	45–54	55–64
7	positive	87.5	65.2	88.9	90.9	37.5	60.0
	undecided	12.5	34.8	11.1	9.1	62.5	40.0
	negative	0.0	0.0	0.0	0.0	0.0	0.0
8	positive	75.0	43.4	44.4	72.7	50.0	20.0
	undecided	25.0	34.8	44.4	0.0	25.0	80.0
	negative	0.0	21.8	11.1	27.3	25.0	0.0
21	positive	75.0	82.6	88.9	90.9	75.0	60.0
	undecided	25.0	13.0	11.1	9.1	25.0	20.0
	negative	0.0	4.3	0.0	0.0	0.0	20.0
22	positive	75.0	91.3	100.0	90.9	87.5	60.0
	undecided	25.0	4.3	0.0	9.1	12.5	20.0
	negative	0.0	4.3	0.0	0.0	0.0	20.0

Although the participants of the course formed a relatively homogeneous group (middle-aged Finnish teachers), there were some interesting gender- and age-related differences in their answers to the questionnaire items. Table 1 sum-

marizes gender and age groups for selected items. It shows that more men (87.5%) than women (65.2%) in the course thought they have better technical capabilities than teachers on average (item 7). Likewise, more men (75%) thought that they have sufficient programming skills as a teacher (item 8). However, more women (91.3% compared to only 75% of the men) agreed that they could teach the contents mentioned in the curriculum by utilizing making (item 22). Interestingly, 100% of the youngest teachers participating in the course agreed with this statement, while only 60% of the oldest teachers agreed with that. Similarly, more women (83% compared to only 75% of the men) thought that making is a pedagogically rational way of teaching (item 22). Again, more teachers of the younger generation agreed with this.

3.4 RQ4: Opinions on advantages and disadvantages of making in teaching and learning

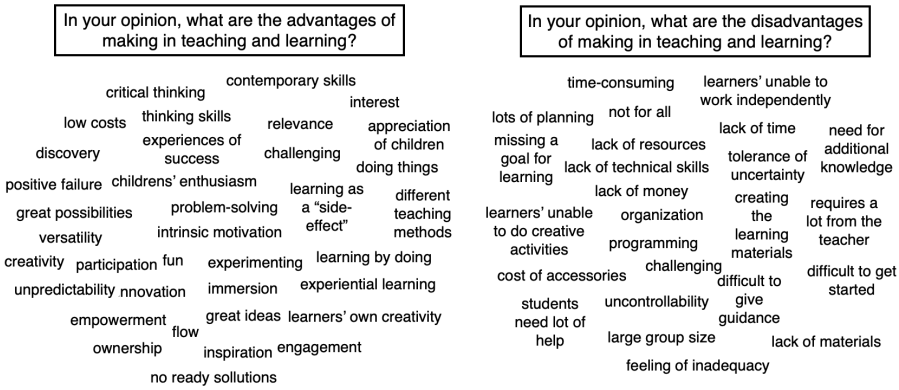

Fig. 8: Keywords extracted from the teachers' open-ended answers concerning advantages and disadvantages of making in teaching and learning.

Teachers wrote about their opinions about the advantages and disadvantages of making in teaching and learning in an open-ended question. All respondents wrote something about the advantages, and all except one respondent also wrote about the disadvantages. Keywords relating to teaching and learning were extracted manually from the answers. Fig. 8 shows the keywords extracted from each question.

The teachers described the advantages of making using vocabulary associated with contemporary discourse about learning (e.g., experimenting, learning by doing, critical thinking, intrinsic motivation, engagement, participation, empowerment). Keywords suggest that the teachers might be able to identify the underlying pedagogical ideas of making (e.g., experiential learning, constructionism, and critical pedagogy). In general, many of the reported advantages relate

to promoting student agency. Reported disadvantages seem to relate to lack of time and resources (e.g., lack of materials, large group size), higher workload (e.g., lots of planning, having to create the learning materials, requires a lot from the teacher), lack of competence, and challenges relating to way of working (e.g., learners' unable to do creative activities or work independently). In the study sample, disadvantages did not seem to relate directly to making as a way of learning. Instead, they are more related to practical teaching arrangements, resources, and to the perceived uncertainty relating to the competencies of teachers and learners.

4 Conclusions and Discussion

This paper presented our preliminary findings concerning the teachers' opinions about *making* as an educational approach after they attended an online course about the subject. In general, the teachers participated in the course because they seemed to be already interested in making, and they had a positive preconception about it. The need for professional development and work-related requirements were also important reasons for participation. Furthermore, as equality is an important topic in the discourse about making in education [1, 12], it is worth noting that half of the respondents were women.

Teachers were technology-oriented, and their opinions about making in education were positive. Teachers wrote about the advantages of making using vocabulary typically used in contemporary discourse about learning. They experienced making as a promising approach for teaching and learning. Even though the teachers were highly technology-oriented, they still considered making as a new and different approach in Finnish schools. The previous interpretation might indicate that making as an educational approach is still a relatively new phenomenon in Finnish schools. The reported disadvantages seemed to relate to teaching arrangements, resources, and experienced uncertainty relating to the competencies of teachers and learners. Due to the small sample size, it is not possible to make far-reaching conclusions. Technology-oriented teachers may have been more likely to apply for the course than other teachers causing a sampling bias. The sampling bias might affect, for example, by giving a too positive impression about making. However, the results suggest that there exists a group of educators who consider making as a positive phenomenon and want to promote its use in schools.

The preliminary results provide guidelines for our future work. We aim to examine teachers educational adoption and use of making. From the digital humanities point of view, the topic is intriguing: making might also be one option to develop skills needed in digital humanities. Making is about building things. If we have at least some agreement that digital humanities might involve "building and making" [14], then digital humanists and makers have a lot in common. In schools, students as makers might be like digital humanists creatively exploring the intersection of technology and the humanities. Possibilities to participate in activities involving creative use of technology might ignite a spark, which en-

courages some of the learners to contribute to the field of digital humanities in the future.

References

[1] B Bevan. "The promise and the promises of Making in science education". In: *Studies in Science Education* 53.1 (2017), pp. 75–103.

[2] P Blikstein. "Digital Fabrication and 'Making' in Education: The Democratization of Invention". In: *FabLabs: Of Machines, Makers and Inventors*. Ed. by J. Walter-Herrmann and C. Buching. Bielefeld: Transcript Publishers, 2013, pp. 1–21.

[3] V Braun and V Clarke. "Using thematic analysis in psychology". In: *Qual. Res. Psychol.* 3.2 (2006), pp. 77–101.

[4] A Burdick et al. *Digital_Humanities*. Cambridge, Mass: MIT Press, 2012.

[5] S Chu et al. "From Classroom-Making to Functional-Making: A Study in the Development of Making Literacy". In: *Proceedings of the 7th Annual Conference on Creativity and Fabrication in Education*. FabLearn '17. New York, NY, USA: ACM, 2017, 3:1–3:8.

[6] E Clapp et al. *Maker-Centered Learning: Empowering Young People to Shape Their Worlds*. San Francisco, CA: Jossey-Bass, 2017.

[7] E Halverson and K Sheridan. "The Maker Movement in Education". In: *Harv. Educ. Rev.* 84.4 (2014), pp. 495–504.

[8] M Koehler and P Mishra. "What is Technological Pedagogical Content Knowledge (TPACK)?" In: *Contemporary Issues in Technology and Teacher Education* 9.1 (2009), pp. 60–70.

[9] J Marshall and J Harron. "Making learners: A framework for evaluating making in STEM education". In: *Interdisciplinary Journal of Problem-Based Learning* 12.2 (2018), p. 3.

[10] L Martin. "The Promise of the Maker Movement for Education". In: *Journal of Pre-College Engineering Education Research (J-PEER)* 5.1 (2015).

[11] K Miller et al. "The Role of Responsive Library Makerspaces in Supporting Informal Learning in the Digital Humanities". In: *Digital Humanities, Libraries, and Partnerships*. Ed. by R Kear and K Joranson. Chandos Publishing, 2018, pp. 91–105.

[12] S Niiranen. "Gender and Technology Education". In: *Handbook of Technology Education*. Ed. by M de Vries. Springer International Handbooks of Education. Cham: Springer, 2018, pp. 875–888.

[13] S Papavlasopoulou, M Giannakos, and L Jaccheri. "Empirical studies on the Maker Movement, a promising approach to learning: A literature review". In: *Entertain. Comput.* 18 (2017), pp. 57–78.

[14] S Ramsay. *On Building*. https://web.archive.org/web/20111016144401/http://lenz.unl.edu/papers/2011/01/11/on-building.html. Accessed: 2019-6-14. 2011.

[15] J Wing. "Computational thinking". In: *Communications of the ACM* 49.3 (2006), pp. 33–35.