Beyond Content: What Else Did Pre-service Teachers Learn in a Making Course in a Teacher Education Program

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Abstract: Making has become increasingly prevalent in K-12 education, thus, calls for teacher educators to design instruction to prepare pre-service teachers for using making as pedagogy. This preparation encompasses not only the technological pedagogical content knowledge involved in making but also the soft skills and a maker mindset. Research on both topics is limited. Thus, the purpose of this study was to investigate what were those skills, habits, beliefs, and practices pre-service teachers gained from a making course. The findings revealed that pre-service teachers acquired 21st century skills. They cultivated a maker mindset. Furthermore, they changed their teaching beliefs. Meanwhile, they made concrete plans for designing and teaching making lessons in practice, professional development, and leadership. The implications were discussed.

Keywords: making, maker mindset, skill, belief, practice, pre-service teacher, teacher education

Introduction

Maker movement was originated from the Do it Yourself (DIY) culture and serves as a political response to industrialization (Dougherty, 2012). A makerspace is “a place where people come together to create and collaborate, to share resources, knowledge, and stuff” (Britton, 2012). The definition of a makerspace is broad and loose because no two makerspaces are the same and there are large varieties of makerspaces in different contexts. For example, academic makerspaces in schools and libraries bring unique opportunities for students and faculty, which could not be easily duplicated in a makerspace for entrepreneurs. As a result, making, which emphasizes the process, becomes a unique approach for students to explore, engage, and learn. Maker education in schools is a combination of making and the integration of technology, which facilitate students to gain both competence and confidence in the subject matter they are learning and the process of learning (Strycker, 2015). Furthermore, maker education helps students develop skills in Science, Technology, Engineering, the Arts, and Mathematics (STEAM) (Peppler, Maltese, Keune, Chang, & Regalla, 2015). Undoubtedly, educators are essential stakeholders in the maker movement who believe that making could potentially transform education (Martinez & Stager, 2013). This firm belief facilitates the emergence of a large number of makerspaces in educational settings.

Educators who support making adopts a constructionist point of view toward learning, which posits that people learn through making (Papert, 1980; Harel & Papert, 1990). With the constructivist and constructionist theoretical foundations (Martin, 2015), teachers follow the eight big ideas in their practice and focus on the “design and construction of personally meaningful projects determined by the learners and not pre-set by others” (Cavallo, Papert, & Stager, 2004, p. 120; Martinez & Stager, 2013).
Researchers have been examining the impacts of making (Papavlasopoulou, Giannakos, & Jaccheri, 2017; Vossoughi & Bevan, 2014). They found that making motivated students learn and develop a deep relationship with learning during the process of completing their projects at hand (Bennett & Monahan, 2013; Resnick, Berg, & Eisenbery, 2000). Moreover, the researchers found that problem-solving through trials and errors led students to a rich learning experience (Petrich, Wilkinson, & Bevan, 2013). Nevertheless, few studies focused on how in-service and pre-service teachers were prepared to use making as pedagogy. In a survey sent to 123 U.S. teacher education programs, Cohen (2017) found that only half of the programs claimed that they offered some kind of making preparation. Nonetheless, for pre-service teachers to become active agents of this promising educational transformation, they need to be fully prepared in their programs. Thereby, the purpose of this study was to investigate what such preparation on using making as pedagogy could help pre-service teachers develop beyond the technological pedagogical content knowledge (Mishra & Koehler, 2006).

Method

Research Context and Participants

The current study was conducted in a Makerspaces in Education course at a teacher preparation program of a large Midwestern land-grant university. This one-credit course is an elective of the Learning Technologies Minor. Pre-service teachers who are enrolled in this minor are required to take 16 credits courses that focus on different aspects of technology integration in the education field. The making course aims to provide pre-service teachers with the necessary knowledge on how to design making lessons in an education Makerspace. It is a four-week course using flipped classroom as its pedagogy (Velegol, Zappe & Mahoney, 2015). Pre-service teachers learned course content online every week, and in class, they worked on hands-on projects. After, they design making lessons and post it online. Four major topics were covered: an introduction to makerspace, physical programming, 2D and 3D digital fabrication, and computer programming (coding). The major assignments are weekly discussion forum posts, hands-on projects, and a final reflection paper.

The participants were the pre-service teachers enrolled in the course who voluntarily participated the study. There were 21 female pre-service teachers who majored in early childhood education, elementary education, and secondary education. All pre-service teachers were enrolled in the Learning Technologies Minor and had finished the foundational educational technology course.

Data Collection and Analysis

A case study approach was used (Yin, 2017). Pre-service teachers’ final reflections were collected because these qualitative data provided in-depth descriptions (Creswell & Creswell, 2018). The final reflection papers used a critical reflection model (Rolfe, Freshwater, & Jasper, 2001). It had a guided structure of three sections, what, so what, and now what. A list of sub-questions was provided as writing prompts.

Directed content analysis approach was used for analysis, which retested existing categories, concepts, models, or theories (Elo & Kyngäs, 2008; Krippendorff, 2004). Through
the review of relevant literature emerged a pre-generated codebook with initial coding categories. The researcher coded the first reflection paper to test the codebook. Afterward, minor changes were applied to the codebook, and the researcher coded all reflection papers. Meanwhile, emerging codes and categories were added to the codebook (Hsieh & Shannon, 2005). After, the researcher combined the codes into categories, theme-related components and then themes.

Results

Developing 22nd-Century Skills for Learning and Teaching

Most pre-service teachers reported that they developed 22nd-century skills after taking the course. They especially developed skills in using technology, generating new ideas, problem-solving, critical thinking, and teamwork.

Pre-service teachers commented that they felt more comfortable and confident in using technology in their instruction. The innovative emerging technology used in the making course was fundamentally different from the other computer technology they learned before, which were both beneficial and “opened the doors to a whole new side of technology.” They also recognized the limitation of a four-week course and were curious about other emerging digital tools. They appreciate the weekly discussion forums that gave everyone an opportunity to explore one more digital tool and share it with the whole class. Collectively, they felt they learned more digital tools as a learning community.

Pre-service teachers reported that they realized that for the hands-on projects they conducted in the course, there were many different ways they could do. Thus, throughout this process, they learned how to generate multiple new ideas and critically think about how to execute each idea, illustrated by this point:

With the little bits, we could have built our windmill different ways; we could have had our windmill do more than just go in a circle going one way only. Same goes for the 3D and 2D printing. We chose to do manipulatives and name tags, but really there is an endless amount of things that could be done with the 3D printer and the Circuit machine. Then came the Spheros, just in our class there were many different projects going on. We had balloon popping, dancing, mazes, and more. The Spheros also have so many different things that can be done with them.

Pre-service teachers reported that they also learned how to generate more new ideas to design engaging lessons because the course required them first to figure out how to use the technology from a student perspective and then to design TPACK lessons as teachers. Furthermore, they stated that when incorporating technology into the classroom, they must critically think about the benefits and feasibility before the implementation.

Pre-service teachers spoke highly of the course because they learned how to problem-solve and work in teams. All projects conducted in the course were complex and required a high level of skills. For example,
One example … was the pinball machine that my group made with Little Bits. We had a tough time figuring out how we would get the flaps to work the way we wanted them too to push the ball back up into the air. We had to cut, switch out, measure, and redo those flaps many different times, but in the end, it worked. The end result was not completely how a pinball machine works, but with more time in class, I am sure we could’ve figured it out!

Pre-service teachers also commented that when facing problems, they felt frustrated. They believed they should learn how to stay calm and patient to solve the problems. Moreover, they said that problem solving and teamwork skills were essential for students to learn and “a good life teaching moment.”

These skills are not only crucial for these pre-service teachers to develop. More importantly, these future educators should learn how to develop students’ skills in their future classrooms, which integrate core subject mastery and contemporary, interdisciplinary themes.

Cultivating a Maker Mindset

All pre-service teachers coming into the making course had minimum experiences with making, reflecting in their belief that they were not makers. However, at the end of the course, most commented that they cultivated a maker mindset. They also said that they developed skills in design thinking and creativity both in making and learning and teaching.

Pre-service teachers spent much time on designing and redesigning their project,

I have also learned a lot about how to plan a design for technological tools; when we worked with littleBits, my group struggled with the design aspect. We had to try and figure out how to make the circuit for a robot, but we also had to design our robot to hold our circuit. After this struggle, I learned a lot about planning a design before executing it. Some of them believed that adapting their design process was the most beneficial part for them as future teachers.

Pre-service teachers believed the making experiences helped them to expand their creativity:

One of the hardest things to do in this class was to decide what to make out of the technology we were using. For example, when we were using the 2D and 3D printers, we had a lot of freedom of what to create. Through this process, my creative thinking skills have strengthened because of this freedom I saw throughout the course. After deciding what to make, I once again had to use my creative thinking skills to design it into a lesson that will be beneficial to teach students.

Meanwhile, they developed a habit of using designing thinking and creativity in their lesson planning. One pre-service teacher commented,

Before the course, I would look at educational technology tools as is. For example, looking at just the surface of Spheros capabilities and saying students can race them.
Instead of breaking down what their potential of programming or designing features that can relate to any subject matter. This experience has taught me to explore the possibilities of tools provided.

Pre-service teachers agreed that design thinking, problem-solving, curiosity, creativity, collaboration, and innovation were essential components of a maker mindset, which they believed they developed in the course. They also commented that there were no limits to the making projects. Mistakes and failure, productive struggle, patience, and never giving up were crucial. They began to think about how to develop students’ maker mindset:

I believe that the course has made a lasting impact on me as a maker because I will want to be thinking of new and creative ways to get students engaged in building, making, and learning all while doing projects that they are interested in. That is what I have found to be a key factor in Makerspace because once a student has interest in what they are doing, they will want to keep learning!

Changing Perceptions and Practice of Learning and Teaching

Most pre-service teachers appreciated that they got the chances to work on the projects instead of just learning about them. Working on hands-on projects was rated highly. They believed this enjoyment would be shared by their future students:

I believe that if the kids are interested in what they are doing, they will learn more. I know kids these days are so in love with technology that they would love these hands-on activities that we could do. If my students are more involved with what we are doing, they are going to learn more and be interested in what we are learning about.

In general, all pre-service teachers wrote about the drastic change in their teaching beliefs, especially transitioning from teacher-centered to student-centered teaching philosophies. Pre-service teachers commented that they believed in the power of hands-on and active learning and technology integration, which “allows students to go above and beyond the content, they are learning in the classroom because makerspace allows students to expand their knowledge on their own terms.” Moreover, they believed in the potentials of making in helping cultivate students’ maker mindset, develop a deeper understanding of subject areas, and gain crucial 21st century skills. Furthermore, they kept emphasizing that the maker mindset and 21st century skills be the keys for students to succeed in the future. They also became more confident and developed self-efficacy:

While I felt challenged while completing the course, I discovered that I am capable of doing phenomenal things using technology and makerspaces. Furthermore, I found that I can create a lesson plan that fits numerous Common Core standards using different means of technology in a makerspace.

Pre-service teachers also made concrete plans for integrating making in their instructions. All pre-service teachers mentioned that they could use the ideas and projects with some adaption and differentiation to grade levels. They also contemplated the design and delivery of their instruction. Pre-service teachers enjoyed the opportunities to create lesson plans to teach Common Core Standards by using making as pedagogy. They wrote about their creative lesson
plan ideas and expressed excitement in teaching those lessons. Most of them also set up detailed plans for building up a makerspace for their future schools. Additionally, they began to think about how to strengthen their leadership and teamwork skills and ask questions as teacher leaders:

How will I go about making it school-wide, which would be the most beneficial for everyone? How will I get the other teachers on board if they don’t know what a makerspace is? If my school already has a makerspace, what are some things that I can do to become involved or to improve the makerspace?

**Discussion**

The results showed that pre-service teachers gained 21st-century skills, cultivated a maker mindset, and changed their teaching beliefs and practices. These findings are encouraging because the skills, mindset, belief, and practice are as necessary as the content. Implications are promising as pre-service teachers potentially will infuse what they learned into their instruction and cultivate students’ skills and maker mindset.

Among these results, cultivating a maker mindset is crucial because the maker mindset is a representation of the growth mindset that leads to creation and innovation (Dougherty, 2016). It is essential for educators to help students learn that people need to be engaged in what they are doing, they need to do something that they love to do and learn through the process, and they need to believe in what they are doing is worth sharing. Cultivating this maker mindset, which is composed of purpose, joy, engagement, focus, flow, persistence, and resilience is necessary (Dougherty, 2016). Once students cultivated a maker mindset, they will strive to learn the content and be engaged in the learning process. Moreover, the maker mindset is what students will need in their life to become life-long learners and makers. Another vital part of the maker mindset that teachers should develop in their students is jumping in and enjoy the learning experiences. Learning is fun and highly engaging and motivating. Different from the traditional teaching method, making and cultivating a maker mindset provide playful experiences for students, which all teachers should strive to provide. Overall, maker mindset incorporates six traits: a sense of curiosity, an interdisciplinary approach to challenges, social-emotional competence through play, a disposition to share and collaborate, a growth mindset, and resilience in the face of frustration (Regalla, 2016). All six are beyond content and should be integrated into the curriculum that prepares students for their life.

Beyond content, teachers should cultivate students’ maker mindset, a can-do attitude. Fostering this mindset is a human project focusing on developing students physically, mentally, and emotionally (Dougherty, 2013). Furthermore, maker-centered learning helps the student develop agency around making stuff and community and build character, such as building competence and confidence and forming identities. Researchers reported that students developed a set of noncognitive skills in making projects, among which “were inspiration, collaboration, a growth mindset, motivation, and development of a failure-positive outlook on the world” (Clapp, Ross, Ryan, & Tishman, 2016, p. 29). Thus, it is crucial to prepare pre-service teachers to use making as pedagogy. However, rarely teacher education programs provide such preparation (Cohen, 2017). Considering the outcomes and benefits of making, teacher educators should offer
more making preparation. Empirical studies are also needed to explore the outcomes and best practices.

Reference


