

Facilitating Makerspace Adoption: Professional Development for University Faculty in Making Techniques and Pedagogy

Dr. Shaunna Fultz Smith, Texas State University

Dr. Shaunna Smith is an Assistant Professor of Educational Technology in the Department of Curriculum and Instruction at Texas State University. She holds an Ed.D. in Curriculum & Instruction with an emphasis on technology integration and art education. Her teaching and research explore how the hands-on use of design-based technologies (e.g. digital fabrication, 3D modeling and printing, computer programming, and DIY robotics) can impact multidisciplinary learning that transcends traditional content contexts (e.g. arts-based STEM integration). At her free mobile makerspace for K-12 students and teachers, The MAKE Lab (<http://themakelab.wp.txstate.edu>), she is currently researching how recurring experiences with these design-based technologies impact visual spatial skills, self-efficacy, and positive attitudes toward failure (e.g. persistence in the face of obstacles; reconceptualization of failure as a paradigm for creative learning) with teachers and K-12 students. These concepts are also part of her research as Co-Director of Bobcat Made, which is the collaborative university makerspace.

Anna H Wakefield, Texas State University

Dr. Kimberly Grau Talley P.E., Texas State University

Dr. Kimberly G. Talley is an assistant professor in the Department of Engineering Technology, Maker Space Co-Director and Senior Research Fellow for the LBJ Institute for STEM Education and Research at Texas State University, and a licensed Professional Engineer. She received her Ph.D. and M.S.E. from the University of Texas at Austin in Structural Engineering. Her undergraduate degrees in History and in Construction Engineering and Management are from North Carolina State University. Dr. Talley teaches courses in the Construction Science and Management Program, and her research focus is in student engagement and retention in engineering and engineering technology education. Contact: talley@txstate.edu

Facilitating Makerspace Adoption: Professional Development for University Faculty in Making Techniques and Pedagogy

Introduction

As part of an NSF-REE funded research project, The Engineering Education Maker Identity Project, this research project seeks to study how students' STEM professional identity was impacted through the inclusion of making and design projects in their courses. The student populations of interest were majoring in engineering, engineering technology, and pre-/in-service STEM teachers. In order to reach this large and diverse group of students, the study needed a sizable and diverse group of faculty members to participate. A call was made to all of the Colleges of Education and of Science and Engineering to reach these student groups, and the resulting faculty participants included Education, Engineering, Engineering Technology, Chemistry, Mathematics, and Psychology faculty. As such, a two-semester professional development program was designed for faculty to 1) learn a variety of maker tools, 2) learn instructional strategies to integrate making and design into their teaching, 3) receive mentoring while developing lessons that integrate making and design into their course content, and 4) build a diverse professional learning and research community for maker integration across disciplines. Beyond recruiting faculty to integrate making and design projects, many interested faculty members wanted to learn making techniques and makerspace equipment to facilitate their classes (and for personal curiosity). The first semester (Fall 2017) involved faculty attending three half-day workshops to learn maker tools and instructional strategies to support the integration of making and design. Workshops were held in two makerspace areas, 1) Bobcat Made - the university makerspace and 2) The Make Lab, low-tech mobile makerspace in the College of Education. Upon attending the workshops, faculty were asked to develop a lesson plan that integrated making and design into one of their courses for the following spring. Faculty participated in online forum discussions and received mentoring from program staff throughout this process. The second semester (Spring 2018) involved faculty implementing the lesson into their course that integrated making and design. With support from program staff and makerspace volunteers, each faculty member was able to bring their students to the Bobcat Made makerspace to facilitate their projects. Data collected included faculty lesson plans and student artifacts. This paper describes the procedure and content of these professional development workshops and describes how some of the faculty integrated making projects in their courses.

Background Literature

Today's academic world is seeing the rise of the makerspace. Following in the footsteps of the maker movement and constructivism, makerspaces are a place where people can come together to explore ideas, create new projects, and build a sense of community. [1] Although they have been around for a little over a decade, makerspaces have been making their way into the education sector over the past few years, and we are faced with the task of evaluating the effectiveness of their implementation as a learning tool.

Maker Ed for Teacher Education

Since using makerspaces is becoming more of a topic for today's education system, it's important that the educators themselves are taught through maker education in order to better understand the learning processes of their students. While there is a danger that educators become enthralled by the "flashy technology-based tools" of the makerspace, it is important that they instead "focus on the pedagogies needed" to create a "meaningful learning" experience for the student body. [2] Something of note is that teachers should not hold the role of the presiding source of information during makerspace learning. Instead the students themselves, through their personal exploration, will be able to learn, teach, and contribute their ideas through collaborative and group activities. [2] By educating current educators and pre-service teachers alike on makerspace etiquette, we are able to provide them with tools to "successfully implement technology in their future classroom instruction." [3]

Maker Ed for University Faculty

While current research does not include the maker education of university faculty, it is important to take a look at the impact maker education of faculty has on university course content and higher education. This paper aims to explore more of this topic.

Maker Ed and Student Learning/Engagement

Most commonly seen as a tool for student learning and engagement, the use of makerspaces in education has shown significant impact on the building of various skills. Although mostly in relation to STEM and engineering education, recent research is showing an increase of makerspace use for other content areas. Due to their open environment and the acceptance of failure as a learning tool instead of a hinderance, makerspaces encourage students to develop "problem-solving, critical and creative thinking, collaboration, and communication skills." [4] It has been shown that allowing students to explore learning through a makerspace increases participation by providing learners with the opportunity to "engage in active thinking and hands-on learning," as well as an opportunity to "bring their interests and ideas" into the space to "make learning relevant." [2] Furthermore, students have been found to be more engaged in makerspace settings where they're excited to use the technologies at their fingertips in order to supplement their learning in a content area. [3] A newfound autonomy in creating their own product motivates students to create and learn, as well as encourage confidence "in their communication and teamwork skills." [5] Overall, makerspaces seem to have a positive impact on student learning and engagement, though best practices for implementation in the education sector are still being explored.

Methodology

Mixed methods were used throughout this study and included a variety of quantitative data (pre-/post-test instrument) and qualitative data (workshop reflections, focus group, lesson

plans, student artifacts); however, this paper only reports on the lesson plans developed by the faculty participants.

Participants.

A call was made to all of the Colleges of Education and of Science and Engineering to seek 20 faculty participants. Faculty participant demographics included 15 females, 5 males, 14 of which taught in the College of Education (COE) and 6 taught in College of Science and Engineering (COSE). The faculty participants taught a wide range of courses but targeted one course to integrate their maker lesson plans. Participants were compensated for the time, which included a \$2,000 stipend upon completion of the entire two-semester professional development program. Table 1 shows the diversity of faculty participant gender, college, department, and targeted courses.

Table 1: Faculty participant demographics.

Gender	College	Department	Targeted Course
F	COE	Curriculum & Instruction (CI)	Talent Development
F	COE	Curriculum & Instruction (CI)	Language and Literacy in Diverse Communities
F	COE	Curriculum & Instruction (CI)	Literacy Instruction for Early Childhood Through Grade Six (EC-6)
F	COE	Curriculum & Instruction (CI)	Literacy Instruction EC-6
F	COE	Curriculum & Instruction (CI)	Science Methods
F	COE	Curriculum & Instruction (CI)	Early Childhood Methods
F	COE	Curriculum & Instruction (CI)	Social Studies Education in Elementary and Middle
M	COE	Curriculum & Instruction (CI)	Integrating Reading and Writing
F	COE	Curriculum & Instruction (CI)	Project-Based Learning
M	COE	Curriculum & Instruction (CI)	Curriculum and Technology in Secondary Education
F	COE	Curriculum & Instruction (CI)	Teaching Reading Across Content
F	COE	Curriculum & Instruction (CI)	Teaching Across the Bilingual Content Areas, EC-6
F	COE	Curriculum & Instruction (CI)	Science Methods
F	COE	Curriculum & Instruction (CI)	Literacy Instruction EC-6
F	COSE	Psychology	Introduction to Psychology
M	COSE	Manufacturing Engineering	Additive Manufacturing
M	COSE	Chemistry and Biochemistry	Peptide Molecules
F	COSE	Engineering Technology	Architectural Design II – Technology in Construction
M	COSE	Manufacturing Engineering	Introduction to Design Theory
F	COSE	Mathematics Education	Mathematics Education

Professional development workshop procedures.

Faculty participants were required to commit to attending a maker-centered professional development program during the fall semester, which included attending three 4-hour workshops. Workshops scaffolded maker-centered instructional strategies, non-digital design techniques, and digital design techniques (as shown in Table 2).

Table 2: Workshop procedures

Session	Topics and Tools
9/22/17 12:30-4:30pm	Design-based learning, making, and 2D design techniques: <ol style="list-style-type: none">1. Creating design challenges2. Alternative assessment strategies3. Basic tour of university makerspace, safety, open lab hours, volunteers, updated website resources4. Non-digital 2D design techniques to create paper craft, including origami, kirigami, and pop-up cards5. Digital 2D design techniques with subtractive manufacturing, including Silhouette Studio software, paper/vinyl cutting machine, Adobe Illustrator, and laser/engraving machine
10/20/17 12:30-4:30pm	Visual spatial skills and 3D design techniques: <ol style="list-style-type: none">1. Interconnections between visual spatial skills, STEM, and the humanities2. Non-digital 3D design techniques with modeling clay, craft sticks, hot glue, and 3D pens3. Digital 3D design techniques with additive manufacturing, including MakerBot PrintShop, Tinkercad, Autodesk Inventor, Makerbot Replicator 3D Printers, and online 3D model databases (Thingiverse, NASA, Project Enable, Smithsonian 3DX, Morphosource, Digimorph)
11/3/17 12:30-4:30pm	Textiles and electronics: <ol style="list-style-type: none">1. Diverse representations of tools and materials in maker education.2. Non-digital textile techniques, including hand-sewing, embroidery, knitting, weaving, and sewing machines3. Digital textile techniques, including Bernina digital embroidery machine4. Non-digital electronics techniques, including LED lights, motors, electrical wires, paper circuits, and sewable circuits5. Digital electronics techniques, including computational thinking, computer programming, microcontrollers, MaKey MaKey, and Arduino
11/16/17 12:30-4:30pm	Optional makeup session: Design-based learning, making, and 2D design techniques
11/17/17 12:30-4:30pm	Optional makeup session: Visual spatial skills and 3D design techniques
12/1/17 12:30-4:30pm	Optional makeup session: Textiles and electronics

Lesson plan development procedures.

During the spring semester faculty participants were asked to implement a Making activity into one of their courses. Each workshop included devoted time for faculty participants to discuss lesson plan ideas with each other and workshop facilitators. In addition, faculty participants were encouraged to submit their initial lesson plan idea to the learning management

system forum, which allowed for additional peer feedback and mentoring from workshop facilitators. Final draft of lesson plans were due at the end of the fall 2017 semester and feedback was given prior to the spring 2018 semester (in time for revision and implementation). A list of open-ended criteria were provided to guide the faculty participants in the development of their lesson plans, which included the following maker-centered instructional considerations:

- **Creation:** Learners are asked to engage in hands-on creation of physical or digital artifacts that support one or more interdisciplinary concepts and learning objectives.
- **Iteration:** Learners are supported to engage in an iterative design cycle that allows for reflection and revision.
- **Sharing:** Learners are supported to collaborate with peers and share their process and/or artifact with individuals beyond the classroom.
- **Autonomy:** Learners are supported to have ownership over decisions regarding the product, the process of creating the product, and/or the ultimate assessment of the work.

Data collection and data analysis.

Final draft lesson plans were analyzed by the researchers using qualitative data analysis software (Dedoose). Deductive coding was used to analyze the lesson plans in relation to areas of maker-centered learning. Codes included maker-centered instructional considerations (i.e., creation, iteration, sharing, autonomy), and instructional strategies (i.e., constraints, demonstration, feedback, formative assessment, lecture, multidisciplinary connections, multimedia instruction, readings, scaffolded activity, summative assessment). It should be noted that this paper reports on a preliminary analysis of the faculty participant lesson plans.

Findings

The variety of targeted courses resulted in a diverse representation of instructional strategies employed by faculty in their lesson plans. Figure 1 shows codes and subtotals from the preliminary analysis. This early analysis shows the frequency with which multiple maker-centered learning strategies were being used within the submitted lesson plans by using a heatmap-style of highlighting higher frequencies. The higher level codes [of Creation, Instruction, Iteration, and Sharing] had the greatest frequencies of being included in the lesson plans along with some other strategy. The sub-level codes of Design Process, Non-Digital Materials, Formative Assessments, Scaffolded Activities, and During Class stood out amongst the sub-level codes with greater than 300 occurrences in the coding process.

Future research goals.

Future research will include deeper qualitative analysis of the faculty lesson plans and student artifacts, including from a curriculum development approach and activity theory perspective by looking at the types of tools and materials they integrated, the course content concepts they connected to, the degree to which they facilitated the making within the course (i.e., community building social constructivist approach, authentic choice-based creative options,

or structured without autonomy), and the ways in which they evaluated student success (i.e., formative, summative).

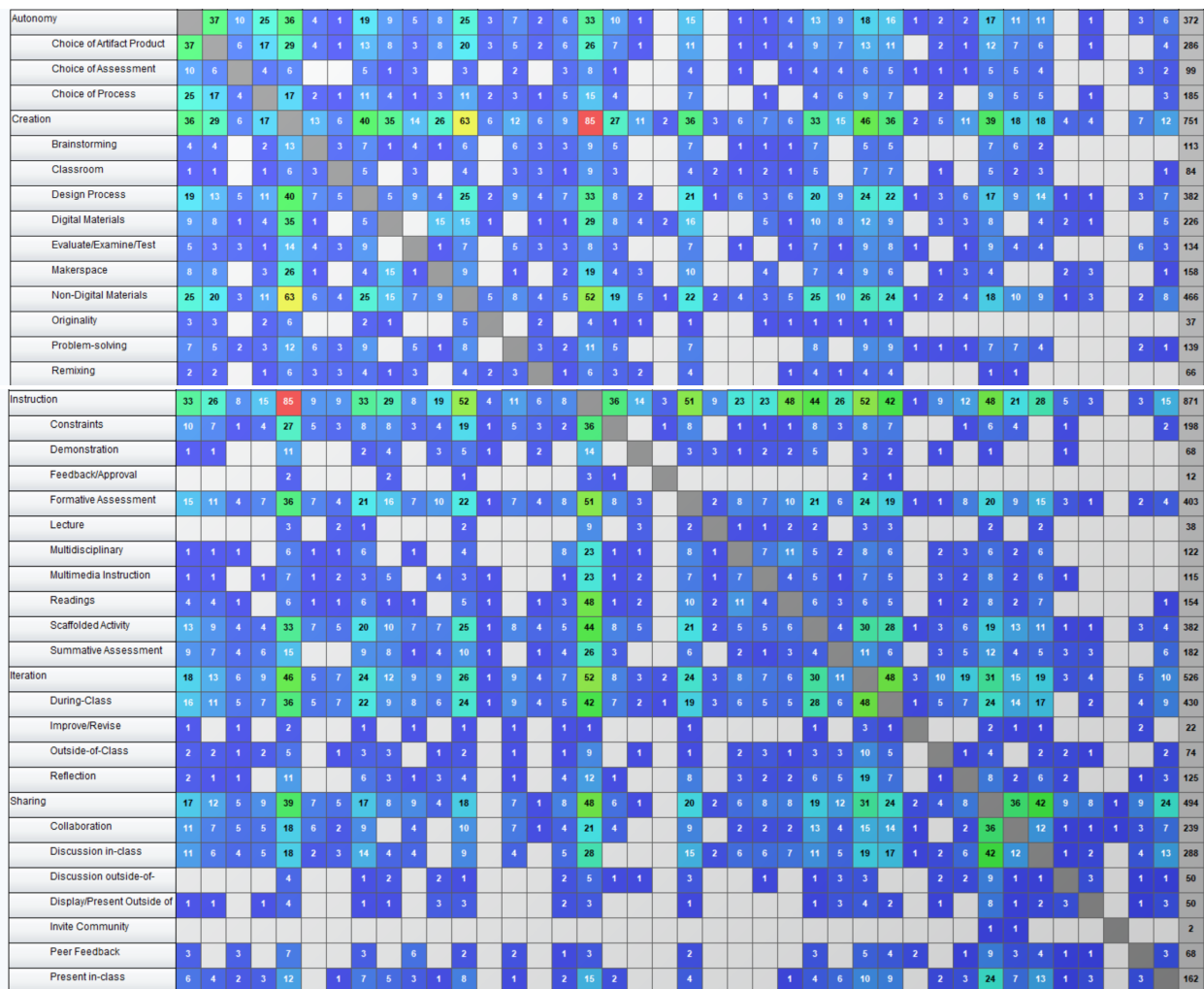


Figure 1: Heatmap of preliminary coding frequencies. The column labels are the same as the row labels as this frequency heatmap examines the intersections of different maker-centered learning strategies.

Conclusion

This paper described the procedure and content of these professional development workshops and presented the preliminary analysis of the faculty lesson plans developed as a part of these workshops. This early analysis showed that popular trends of implementation included in class projects that features non-digital materials, formative assessment, and a discussion of the design process. The higher population of College of Education faculty versus College of Science and Engineering faculty could mean that these trends were skewed by the larger faculty population from one college, however analysis of faculty lesson plans separated by college has not yet been conducted. What can be seen are the ways that this group of faculty have integrated

maker-centered learning into their diverse courses. The considerable diversity in strategies implemented could be a result of both the diversity of faculty as well as the course topics.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. EEC 1531375. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

- [1] H. (2018, September). Why did Maker Faire start? And, what is the Maker Movement? Retrieved January 31, 2019, from <https://help.makermidia.com/hc/en-us/articles/204141849-Why-did-Maker-Faire-start-And-what-is-the-Maker-Movement->
- [2] Peterson, L., & Scharber, C. (2017). Learning About Makerspaces: Professional Development with K-12 Inservice Educators. *Journal of Digital Learning in Teacher Education*, 34(1), 43-52. doi:10.1080/21532974.2017.1387833
- [3] Song, L. (2018). Improving Pre-Service Teachers' Self-Efficacy on Technology Integration Through Service Learning. *Canadian Journal of Action Research*, 19(1), 22-32. From <https://journals.nipissingu.ca/index.php/cjar/article/view/373>
- [4] Sheffield, R., Koul, R., Blackley, S., & Maynard, N. (2017). Makerspace in STEM for girls: A physical space to develop twenty-first-century skills. *Educational Media International*, 54(2), 148-164. doi:10.1080/09523987.2017.1362812
- [5] Galaleldin, M., Bouchard, F., Anis, H., & Lague, C. (2017). The Impact of Makerspaces on Engineering Education. *Proceedings of the Canadian Engineering Education Association (CEEA)*. doi:10.24908/pceea.v0i0.6481