Towards an Inclusive Model of Makerspace Educator Professional Development: Implications for Students with Disabilities and At-Risk

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ABSTRACT

This paper describes exploratory research that contributes to a more holistic model of professional development (PD) for middle school STEM teachers to support inclusive makerspace classrooms. Despite an increased focus on maker education in K-12 settings, teachers have reported limited support to deliver such instruction, especially with academically diverse learners. This case study examined instructional supports for teachers, including professional development and coaching focused on makerspace classroom activities, as well as structural conditions, the integration of metacognitive learning strategies, positive behavior supports, and Universal Design for Learning (UDL). Analysis of teacher interviews, surveys, and classroom observations revealed that teachers acknowledged the need for ongoing PD and the inclusion of UDL components into their lesson planning.

Keywords

Inclusive Education; Middle School; Metacognitive Strategies; Science; Technology; Engineering; STEM; Makerspaces

1. INTRODUCTION

Experiential learning or learning by doing, which is one of the affordances of making, is increasingly seen as beneficial to cognitive development among students (Halverson & Sheridan, 2014). An ongoing discussion of school-based making is focused on a number of issues, including: (a) how to fit the makerspace activities within the structured curriculum of the formal education program, (b) what classroom-based makerspaces and connected activities should look like, and (c) what skills and perspectives students are to learn from these spaces (Hira, Joslyn, & Hynes, 2014). Consideration is also increasingly focused on professional development for teachers. For example, concerns about the inclusion of makerspaces in K-12 settings are focused on the type of expertise required to teach this skill-based subject, the content of in-service and preservice instruction, the type of preparation considered appropriate for teachers' professional development, and the nature of management support required to help novice maker teachers be able to implement making activities in a robust manner (Oliver, 2016). Additionally, in assessing the makerspace literature, it becomes evident that efforts are needed to improve accessibility and inclusion for a wider range of learners, including those with a range of disabilities (Stark, McNair, & Riley, 2018). However, endeavors seldom address those with disabilities be they physical, cognitive, or behavioral (Brady, Salas, Nuriddin, Rogers, & Subramaniam, 2014). Brady et al. (2014) examined the criticality of making activities for those with disabilities given that "participating in makerspaces may provide a venue in which individuals with disabilities can thrive and experiment with problem solving, in addition to the space being interactive, fun, educational, and meaningful" (p.331). Therefore, thoughtful consideration must be applied in planning for inclusion, adaptations, and accommodations in the physical space as well as with the technology and instruction (Klipper, 2014). These necessary components for inclusive making can be supported through practices such as alternative entry points for accessing the making activities, modeling the use of tools, materials, problem solving strategies, scaffolded learning, and personal relevance that benefit not only those with disabilities but all learners (Hughes, Fridman, & Robb, 2018).

With the growing presence of making in formal K-12 education, there is a need for maker-specific professional development (PD) to ensure effective and sustainable practices for this distinctive pedagogical approach to learning and the tools it utilizes. Taking into account the significant role that teachers play in the success of students, there is a need to "identify elements of effective instruction that positively correlate to student achievement and other student outcomes such as efficacy, academic persistence, and a positive affect for learning" (Marshall, Smart, & Alston, 2016, p.160). Given that making is in the developmental stages of implementation in formal education settings, it is imperative that PD be established that not only addresses content but provides strategies for inclusive instruction that supports cognition, engagement, and accessibility (Oliver, 2016).

1.1 Related work

While an encouraging presence of studies have begun to examine the framework of makerspace PD for K-12 teachers, they often do

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not address the presence or need for accessibility accommodations for diverse learners. Two previous studies highlight the appreciation for teachers experiencing making from the learner perspective and reflection on equity-oriented strategies and experiences for the makerspace PD for K-12 teachers (Paganelli et al., 2017; Peterson & Scharber, 2018). Paganelli and her colleagues (2017) recognize the importance of teacher participation in makerspace activities in order to better understand the means by which students navigate the making process as well as many of its inherent characteristics and challenges. Another PD model by Peterson & Scharber (2018) delves deeper into the complexities of making pedagogy that immerses teachers in more sustained making experiences and fosters dialogue about equity-oriented concerns such as "Are multiple pathways and ways of knowing supported or marginalized?" (p.50). Emphasis is also given to the development of the maker mindset, particularly its focus on the use of fast, iterative failure as a tool for learning. These two studies identify the necessity to revise PD in order to integrate the learner experience and equitable approaches to making that attend to concerns for who has access, patterns of participation, and supports for inclusion. Given the importance of ensuring access to making activities for all learners, the current study suggested a new PD model for STEM teachers in a K-12 setting.

2. RESEARCH DESIGN

The research reviewed here was conducted as part of a larger multi-year study that focused on engagement and barriers followed by the investigation of cognition and metacognition in independent student learning experiences. This paper focuses on related research findings connected to the professional development and intervention that was conducted as part of that study, as well as implications for next-steps and best practices. This sets the stage for our driving inquiry. Given the barriers and successes observed during this study, what are the implications for professional development for makerspace educators?

We employed a cross-case qualitative approach (Stake, 2006) to understand the experiences of four general education teachers in meeting the needs of students with disabilities and students at- risk for academic failure in middle school maker learning activities. Each case was initially examined independently as a unique instrumental case study. Then, the cases were grouped into a multi-case analysis so they could be compared for similarities and differences.

2.1 Participants

For the current study, four teachers were recruited from two school districts in a mid-sized urban community in the Midwestern United States during the 2017-2018 academic year. At the time of this study, District U had 100 8th grade students in a year-long science class taught by Ms. Leslie (11 years of teaching experience). While District X had 180 students in grades 7-8 each quarter in technology-based STEM classes taught by Ms. Morgan (7 years), Ms. Collins (20 years), and Mr. David (1 year).

2.2 Data Collection

This was a two-phase study. In phase one, researchers collected the teacher interview and classroom observation data in the spring of 2018 in each of the four classrooms for 8 to 12 days of an instructional unit (i.e., making activities). In phase two, researchers collected the data in two classrooms (e.g., Ms. Leslie and Ms. Collins) in the fall of 2018 including pre-PD and post-PD teacher surveys, and classroom observations.

2.2.1. Teacher interviews

During phase one, all four teacher interviews were collected. An interview protocol was developed based on previous literature (Hira et al., 2014; Seymour, 2018). Interview questions were framed around teaching and PD experience (i.e. How were/or were you able to integrate the new learning into your lesson plans?), facilitation strategies for persistence and intentionality (i.e. What strategies do you use to demonstrate intentionality to students in working on a project?), and successes and challenges for students with disabilities (i.e. How are students accommodated and taught in alternative ways to begin to think about thinking and using metacognitive strategies?). One researcher conducted semi-structured interviews with all four participants after the instructional unit was completed.

2.2.2. Teacher surveys

To understand the needs for PD, the research team developed a pre-PD survey with open-ended questions. The pre-survey questions included: "What are your goals for this week of professional development? What/if any issues do you have in your classrooms you would like to address with this professional development team? What are your top 3 priorities for learning/experiencing during this week of professional development?" After completing the PD, teachers were asked to complete another survey to reflect their learning from the workshops. The post-survey questions included: "Briefly summarize your initial goals for this week and explain to what extent and how you have met your goals during this week of professional development? What will you consider doing differently in the way you approach your curriculum and/or teaching methods this year?"

2.2.3. Classroom observations

For both phase one and two, two observers were present in the classroom across the entire instructional unit. A teacher observation instrument was developed by the research team based on the pilot findings and literature review. Based on the teacher observation instrument, two observers wrote the field notes including resources, student engagement, instructional strategies, teacher movement, and barriers.

2.3 Data Analysis

Researchers reviewed the interview transcripts, survey responses, and observation field notes to pull emergent themes using qualitative, open-coding. During the first round of coding, researchers focused on current teacher experiences (e.g., previous PD participation, instructional support needs). The transcripts were then re-coded using the PD framework for middle school teachers: metacognitive strategies, positive behavior support, universal design for learning, and maker-related content). Inter-rater reliability was calculated to ensure reliability of the coding process. For the current study, Kappa was .82.

3. RESULTS

Findings from this study are presented through a two-phase implementation process. The first phase was a pilot implementation of making activities in middle school classrooms, and occurred prior to the PD. In the second phase, teachers were afforded PD and coaching before they implemented making activities in their classrooms.

3.1 Phase One: Pilot middle school makerspace implementation

In the 2017-2018 academic year, the four teachers implemented different maker activities for their individual STEM and science classrooms that they had found and adopted (or adapted) as part of

their regular curriculum. During this phase, the research team observed and interviewed the teachers with the aim of understanding how teachers presented makerspace activities to students, and the challenges of doing so. All four teachers reported limited PD participation in the past and expressed their needs for additional STEM-related PD, including makerspace PD. Mr. David and Ms. Morgan acknowledged that their lack of participation in maker-specific PD had resulted in them feeling less confident teaching activities with new equipment like 3D printers.

Findings from phase-one classroom observations were in alignment with the teacher interviews. The execution of activities was noted as having the potential to be enhanced through further understanding of critical maker elements such as tinkering, iteration, and reflection. In addition, student disengagement was a common concern for teachers as they reported difficulty engaging students with disabilities or at-risk in the activities. Repeated observations of student disengagement further indicated a need for projects that provided more choice and that allowed for cultural relevance and equitable participation. On a related note, Universal Design for Learning (UDL) strategies, which promote students' engagement, were limited. These potential challenges for successful implementation of making activities suggested the need for PD with not only maker-related resources but also including instructional and behavior management strategies to promote inclusion of students with disabilities and at-risk.

3.2. Phase Two: Professional Development and Coaching for Maker Activities

In phase two, teachers participated in an all-day, week-long PD (summer of 2018) as well as embedded coaching (fall of 2018).

3.2.1 Summer Professional Development

Based on feedback from phase one, PD sessions were developed to be mindful of teacher's priorities, which included learning ideas for making in the classroom with specific tools and technologies that provide engaging, sustainable, and student choice-driven activities, vetted resources (i.e. Makey Makey), and building a community of practice. The PD began by defining the elements of an inclusive making activity with teachers. The making elements were based on seminal maker literature along with the goals of the research study and included playful tinkering and experimentation, design through remixing and reverse engineering, collaboration and shareability, access, planning, iteration, and reflection, and equitable participation. This was immediately followed by teachers engaging in a maker project that demonstrated that making activities alone cannot deliver the learning objective of accessible making but must be supported with appropriate teaching practices (i.e. modeling) and an environment that fosters inclusion (i.e. multiple entry points). To foster inclusion in makerspace activities, PD included two sessions on methods of implementation of UDL and positive behavior supports. UDL considers the needs of all students from different backgrounds based on three principles (i.e., multiple means of representation, expression, and engagement). The week continued with more opportunities for educators to self-select and be immersed in a diversity of making opportunities, thus gaining experience in employing these techniques and resources.

After PD, teachers completed the post-PD survey and reported two main outcomes. First, teachers learned more hands-on maker activity options for greater student engagement and that could be easily adapted and integrated into the classroom. Second, teachers learned how to design making activities incorporating strategies to include all learners, specifically UDL. For example, teachers noted their interest in bringing in elements such as choices, modeling, and modality, which are all critical to UDL.

3.2.2 Embedded coaching and support

While the intensive PD provided a framework for adapting inclusive making into the classroom, teachers required sustained supports. This was accomplished through continued coaching throughout the development and implementation of making activities. Just as no two makerspaces are identical, the coaching provided to the teachers of this study was tailored to meet their specific needs in their particular maker setting. The teacher-coach collaborations were reflective of what each teacher sought to bring to their classroom.

In one teacher-maker coach partnership, the teacher recognized from the summer PD the importance of tinkering as a pathway for engagement with making and has implemented a 'Tinker Thursday' for students to explore new technologies and design challenges. A positive effect was observed as students gained comfort with the open-end experiential learning and began to adopt a 'maker mindset'. The playful nature of this activity has supported student engagement and intentionality that will be valuable in fostering metacognitive skills.

In addition, the teacher and maker coach worked in partnership to develop a making activity for the classroom that was based on vetted maker resources. Brainstorming and timing of the making activity were thoughtfully considered. The project was further developed to address scaffolding toward a UDL approach to making (accommodations, learning outcomes, big idea, scaffolded learning, collaboration, and project elements). Fundamental tenets such as student choice and scaffolded learning paths were incorporated into the activity as well as encouraging students to integrate prior learnings from 'Tinker Thursdays' and making materials experiences.

In contrast, the mentoring relationship with another teacher in the study focused on guided implementation of making resources that could enrich preexistent activities. An established teacher with effective teaching strategies, this teacher looked to the maker coaches for expansion ideas, appropriate resources, and training on the maker resources that would be implemented during the lessons due to newness to making and insufficient time.

Table 1. Phase two: PD and Embedded Coaching

Teacher Development Needs	Initial PD	Embedded Coaching
Understanding maker experiences / Fluency in technologies and tools	-Expose teachers to what making is -Provide hands-on practice opportunities as a learner with tools and activities (e.g., Makey Makey)	-Instruction and modeling for teachers on how to use resources, tools, and technologies -Model perseverance and support teachers' debugging and problem-solving -Provide lesson-planning supports and resource sharing
Understand learner variability	-Introduction to UDL and Accommodations -Introduction to balancing explicit instruction within open-ended maker activities -Discussion of culturally responsive pedagogy within making - Introduction to Positive Behavior Support	-Provide teachers with applied UDL and making checklist and accommodation examples -Review or co-develop the lesson plan -Encourage teachers to utilize student collaboration -Give feedback on and promote intervention for learning gaps and troubleshooting
Design of Making activities	-Discuss making activities as a way to enhance depth of learning	- Extension and enrichment of existing classroom curriculum - Development and implementation of new making resources and activities
Metacognitive Strategies	-Introduction to metacognitive strategy index (i.e., intentionality, iteration, persistence) - Discuss the nature of making activities	-Reminders to scaffold learning with prompts for self-reflection, questions about purpose and function of the student product

Overall, the relationship between teachers and maker coaches further instilled the importance of creating a community of practice. Maker coaches promoted vetted making resources and ideas while teachers facilitated the understanding of authentic learning needs of

students. Both benefited from each other's knowledge in working toward a more inclusive making experience in the classroom.

4. DISCUSSION

While maker activities are open to all learners, previous PD has not addressed how to support K-12 teachers to promote inclusive maker activities. Overall, our findings highlighted limited pedagogical practices to address a broad range of learners in classrooms. Given the challenges faced by the teachers, the research team developed a new PD framework to support inclusive maker K-12 classrooms by incorporating UDL principles. A primary contribution of our PD model to the literature is the addition of effective instructional and behavioral strategies to support diverse learners, specifically targeting students with disabilities and at-risk. See Figure 1. While previous PD models highlighted the problem-solving and design thinking in application of projects (Paganelli et al., 2017; Peterson & Scharber, 2018), it might not be sufficient to support a range of diverse learners.

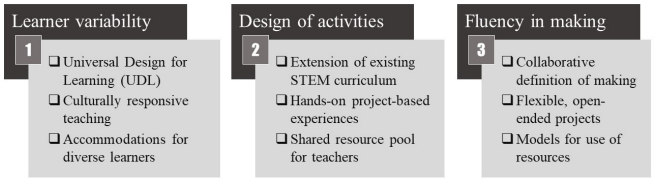

Figure 1. Professional Development Framework

To resolve this issue, it was essential to incorporate not only fluency in making but address learner variability in PD sessions. To do so, the current study suggested addressing specific instructional strategies (i.e., UDL, explicit instruction, culturally responsive teaching, accommodations) during PD. Further, embedded coaching encouraged implementation of different instructional strategies into lesson plans. Similar findings from Israel et al. (2018) found coaching in STEM K-12 classrooms to be effective in promoting inclusive classrooms; the current study reinforces coaching as a crucial support for teachers.

Several limitations should be considered when interpreting these results. As phase two is only implemented with two teachers, it is difficult to generalize the findings. Future research should examine the impact of PD on K-12 teachers with a bigger sample. The present study also only included teachers, not students. To understand how PD and coaching works, future research should collect student data (e.g., interview, survey, or observations). Nonetheless, by identifying supports for teachers in making activities, as well as instructional strategies, researchers may help other STEM teachers use practices that support more diverse student populations.

Therefore, continued supports should be considered such as the development of modules for preparing inclusive making activities. These modules may include introduction to specific instructional strategies (i.e., modeling, prompting, organizing structured classroom, using visuals), positive behavior supports (i.e., rewards system), metacognitive strategies (i.e., persistence, intentionality), and making activity suggestions. Nevertheless, the criticality of these resources is only as effective as the affordance of time given to teachers to cultivate their knowing through doing, further pointing to the need for a community of practice where educators can engage, collaborate, and share with other educators and makers. Efforts such as these help provide what Schneider has termed the "last mile program" in which effective research education strategies need to be provided to teachers that are viable to streamline into classroom instruction (Schneider, 2018).

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