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University Makerspaces as Sites for Pre-Service STEM Teacher Preparation

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ABSTRACT

University makerspaces are promising sites for pre-service STEM teacher preparation. By engaging in structured learning experiences in university makerspaces, pre-service STEM teachers gain valuable knowledge, skills, and practices. In addition, these learning experiences highlight the integrated nature of STEM and aid pre-service STEM teachers gaining instructional confidence.

Keywords: University Makerspaces, STEM Education, Pre-Service Teachers

INTRODUCTION

In today's rapidly evolving technological landscape, science, technology, engineering, and mathematics (STEM) education is key to cultivating students' creativity and future-ready competencies. Achieving this goal requires the preparation of pre-service teachers with the pedagogical knowledge and experience needed for educating students of the future. In response to this challenge, the use of university makerspaces to educate pre-service STEM teachers has recently increased (Heredia & Fisher, 2022; Quintana-Ordorika et al., 2024). This increase is due, in part, to the recognition that participants in makerspaces are exposed to a variety of technologies (e.g., digital fabrication), practices (e.g.,

design thinking), and twenty-first-century skills (e.g., problem solving, creativity) that are beneficial for STEM educators (Soomro et al., 2023). In addition, educational researchers have found that providing pre-service STEM teachers with rich learning experiences in university makerspaces may better prepare them to teach STEM concepts using their own school makerspaces in the future (Rouse et al., 2025). In this paper, we provide background and rational for researchers and practitioners who are interested in preparing pre-service STEM teachers using university makerspaces. Throughout the paper, we take the stance that using university makerspaces as sites for pre-service STEM teacher preparation is promising, aligns with contemporary views of STEM education, and can be done internationally.

THE LANDSCAPE OF INTERNATIONAL STEM EDUCATION

Over the past decade, researchers and practitioners around the globe have advocated for a more integrated STEM education (National Research Council, 2014; Razi & Zhou, 2022). The move toward integrated STEM (iSTEM) is driven by the understanding that STEM subjects do not exist in isolation and that outdated views of STEM education focused too much on instruction in distinct content areas rather than on exploring the interdisciplinary nature of STEM subjects (Blackley & Howell, 2015; Kelley & Knowles, 2016). As the move towards iSTEM education continues, novel methods for preparing pre-service STEM teachers are underway (Blackley et al., 2017; Stevenson et al., 2019). Many of these efforts are meant to ensure the next generation of STEM teachers will be equipped to teach in ways that maximize the interdisciplinary nature of STEM subjects. Thus, it is important for educational researchers and STEM teacher educators to continue to seek out new ways of preparing STEM teachers. University makerspaces have emerged as particularly promising venues for pre-service STEM teacher preparation because they promote their participation in activities that span STEM disciplines, expose them to new technologies and pedagogies, and boost their confidence teaching STEM content.

UNIVERSITY MAKERSPACES AND STEM EDUCATION

Makerspaces, locations equipped with a variety of digital and physical tools and technologies, are places where individuals come together to create all manner of artifacts based on personal interests (Sheridan et al., 2014). Importantly, participants engage not only in the technical aspects of making, but also in the community practices, such as collaborating, troubleshooting, and sharing knowledge and skills with other members of the makerspace (Peppler & Bender, 2013). It was this unique combination of tools, mindsets, and culture that made makerspaces appealing places to move into academic environments. And although many of the earliest makerspaces were developed in community settings in the United States, the model was later adopted by universities and has since spread to

institutions across the globe. Indeed, makerspaces have been important fixtures on university campuses for some time (Barrett et al., 2015). Many early university makerspaces were created in schools of engineering to meet the needs of undergraduate students where much of the programming and activity in the makerspace revolved around servicing engineering students (Taheri et al., 2020). However, educational researchers and teacher educators soon saw the potential of makerspaces for teaching and learning and have since included them as sites for pre-service teacher preparation (Quintana-Ordorika et al., 2024).

UNIVERSITY MAKERSPACES AND PRE-SERVICE TEACHER PREPARATION

With the number of university makerspaces steadily rising internationally, it made sense for educational researchers and teacher educators in different countries to begin exploring how to incorporate making and makerspaces into pre-service teacher preparation programs. One of the earliest studies to investigate pre-service teachers' experiences with making at a university was Cohen et al.'s (2017) examination of educators' perceptions after engaging in a semester-long maker-focused university course. Cohen and colleagues created the specialized course for students, the majority of whom were pre-service teachers, to expose them to maker-based teaching and learning. Throughout the course, students reflected regularly on their maker-based learning experiences—experiences that included activities such as designing and building an arcade game. Cohen et al. found that the experience resulted in participants perceiving maker-based learning as beneficial because of its many opportunities for collaboration and for its use in establishing a strong classroom community. These findings support the claim that providing these types of experiences to pre-service teachers may translate into in-service teachers fostering collaboration and community in their own school makerspaces in the future.

Heredia and Fisher's (2022) study extended Cohen et al.'s (2017) work by moving pre-service teachers' experiences with making into a university makerspace. Heredia and Fisher's Maker-in-Residence program offered pre-service teachers opportunities to volunteer in the university's makerspace. As volunteers, participants developed their skills using the tools and technologies in the makerspace, created personalized objects, and assisted other pre-service teachers using equipment in the makerspace. As a result of the experience, participants gained confidence using makerspace tools and technologies and developed a mindset that the iterative work that occurs in a makerspace can be collaborative and fun. According to Heredia and Fisher (2022), pre-service teachers who participate in activities in which they build knowledge and practice in a university makerspace are better prepared to do the same with their own students in school makerspaces in the future.

A recent study by Halliburton et al. (2024) blended aspects of Cohen et al. (2017) and Heredia and Fisher's (2022) work together. In their study, Halliburton

et al. investigated pre-service teachers' confidence in STEM. To do this, they created an open-ended STEM-focused task and included it as a component of an existing science methods course. The task required participants, who were all pre-service teachers, to use the tools and technologies in the university's makerspace to create STEM kits that could be used by teachers and students in schools. Throughout the project, participants had easy access to the makerspace to complete their projects. Halliburton et al. found that this experience increased participants' confidence working in makerspaces and teaching STEM concepts. Importantly, this study illustrates just one of the STEM-related benefits that incorporating university makerspaces into pre-service STEM teacher preparation can provide.

This small collection of studies helps to demonstrate the large potential of using university makerspaces as sites for educating pre-service STEM teachers in the future. These studies also highlight that although the infrastructure may be in place at many universities to begin exploring the benefits of incorporating university makerspaces into pre-service STEM teacher preparation programs, this is still a field that demands more investigation. As the number of university makerspaces continues to increase, there will be more opportunities for educational researchers and teacher educators to study the effects of incorporating university makerspaces into pre-service STEM teacher preparation programs.

NEXT STEPS FOR PRE-SERVICE STEM TEACHER PREPARATION

The future of using university makerspaces for pre-service STEM teacher preparation is bright. In the past, university makerspaces were uncommon and had a narrow focus. Now, however, makerspaces are widespread on university campuses, and many of those makerspaces can serve as sites for preparing pre-service STEM teachers. In addition, there is also agreement on the value of iSTEM education and the need to emphasize the interdisciplinary nature of STEM subjects. This value focus can be supported by providing pre-service teachers with learning experiences in university makerspaces.

Educational researchers and teacher educators have only just started to explore the impact of incorporating university makerspaces into pre-service STEM teacher preparation programs. At a minimum, experiences in university makerspaces are beneficial because they give pre-service STEM teachers a well-rounded view of what happens in iSTEM education—allowing them to visualize clear connections between different subjects. These experiences also have the potential to support pre-service STEM teachers developing mindsets that embrace designing, iterating, and learning through failure. Finally, these experiences may provide an opportunity for pre-service STEM teachers to connect explicitly to STEM concepts in the curriculum and may also include hands-on activities that pre-service teachers can replicate with their own students in school makerspaces when they begin teaching.

For those educational researchers and teacher educators interested in taking up this work, we recommend reaching out to university makerspace

directors to discuss possible collaborations. We have found that the culture of makerspaces is such that many university makerspace directors are eager to expand the impact of the makerspace by inviting new groups to enter the space and participate by making personalized artifacts with the various tools and technologies in the space.

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