Mobility, Diversity, and Openness: Design Principles for Equitable Makerspaces

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Abstract: As makerspaces become ubiquitous, they need to remain equitable environments for teaching and learning. Building on inquiry of diverse makerspaces, we identified three design principles of equitable environments (i.e., mobility, diversity, and openness) and leveraged them for one of the first university school of education makerspaces. We present the design principles, their application, and implications for the design of future makerspaces, particularly those that support pre-service teacher education.

Keywords: makerspace, school of education, design principles, pre-service teachers

Roots of making and a pedagogy for teacher education

Embodying the do-it-yourself ethos and celebrating technological innovation, makerspaces have surged over the past decade, rapidly spreading in schools, libraries, museums, and after-school centers (Peppler, Halverson, & Kafai 2016). This surge may be too brisk to keep pace with innovative educational design needs, as there is underdeveloped certainty about how these spaces can avoid repeating prior inequities in STEM-based environments. Higher-education-based makerspaces are important because they present opportunities to model high-quality educational practice for future teachers placed in a multitude of schools and afterschool programs. Makerspaces promise a real opportunity for more inclusive teaching and learning, provided we build them using appropriate design principles, humble theories that guide affordances toward improved learning (Rook, Choi, & McDonald, 2015). Makerspaces have been aligned with principles of constructionism (Resnick & Rosenbaum, 2013), an approach to learning in which learners come to know the world through design as they create personally meaningful projects that can be publicly shared (Papert, 1993). As makerspaces move into schools and teachers facilitate content knowledge through maker activities (Peppler, Halverson, & Kafai, 2016), there is a need for pre-service education that supports future teachers to explore constructionist learning before entering the profession. Aspects of successful preparation of future teachers and professional development opportunities of in-service teachers include the creation of contexts that are conducive for reflecting on practice and developing new approaches to teaching and learning (Vescio, Ross, & Adams, 2008). Despite the urgency for teachers to be able to use emergent technologies and the promise of makerspaces to support this exploration, the design of learning environments in pre-service teacher education remains under researched.

Methodological approach

Our makerspace design approach builds on design-based research, a methodology in which researchers and practitioners collaborate to iteratively analyze, design, develop, and implement learning experiences in real-world settings (Wang and Hannafin, 2005). One pillar of design-based research is the distillation of *design principles*, localized guiding theories that improve learning (Rook et al., 2015). This poster focuses on design principles to guide the development of new makerspaces that promote equity through a two-phase process.

Phase 1 adopts a qualitative contextual inquiry. We surveyed 51 and observed 10 makerspaces that encourage equity through educational practices and materials and serve diverse demographics. Based on qualitative observations and in-depth interviews with mentors and youth, we distilled design principles through a reversed conjecture mapping process (Sandoval, 2014). Phase 2 is comprised of testing and refining the design principles through research-based design (Leinonen et al., 2008). We analyzed how the design principles and their form impacted pre-service education throughout the first year in which the makerspace was open.

Design principles and development of the makerspace

The makerspaces we observed included a wide range of materials and exhibited a range of youth projects. All makerspaces were situated inside of open studio spaces where youth could see what others were engaged with. Ceiling electricity, mobile tables, and concrete floors supported the setup of workstations that flexibly accommodated project needs presupposed that makerspaces change over time as projects evolved and new materials entered the space. Based on these commonalities, we distilled three guiding principles: (1) *Mobility* to arrange workstations according to learning needs, (2) *diversity* of materials to support a broad range of

approaches to making, and (3) *openness* of access to materials for youth of all ages. To test the design principles, we used them to guide the spatial arrangement of the university makerspace as a way to spark possibilities particularly for pre-service teachers for modelling community-based and open-ended learning.

To support *mobility*, we ordered height-adjustable tables, custom storage units that tucked under counters or generated work surfaces, exposed the concrete floor to move furniture with less friction, and installed metal pegboard along walls for continuous space rearrangement. To invite *diverse* approaches to making, we made the space wheelchair accessible. We engaged material historicity (Buchholz et al., 2014) by considering participants' gender and age, stocking the space with a range of materials, and established faculty grants that included allocations for material purchase. As architectural plans were created, we focused on *openness* to make materials, projects, and practices visible and accessible for people both familiar with and unfamiliar with making. This led us to tearing down walls and instantiating an open door policy.

Once the space opened, design continued. People created projects, moved furniture, and asked for additional materials. We observed how the design principles and their material implementation acted within the institutional space of the school of education. Against our expectations, the mingling of materials did not happen as frequently. For instance, most 3D printed models remained on the right side of the space while most laser cut projects were displayed on the left side. Assumptions about learning that were embedded into the institutional setting, such as working on individual projects in designated seats and all classrooms to be of similar sizes and shapes, were challenged through new maker materials that called to move across the space and to share work openly with others. The variety of materials visibly accessible at the makerspace invited people to try new tools and techniques, resulting in a variety of projects, including laser-cut dinosaur puzzles, a 3D model for teaching Tai Chi, and art and science education tools. Faculty grants broadened material diversity, as projects brought in toys and gluten-free playdough. The makerspace was rearranged frequently, as people shifted the tables and storage carts across the room to create unique workspaces. The ceiling-mounted electrical cords were pulled towards workspaces to maintain and break existing setups, underscoring the mobility of space, and allowing for continued adjustment. The design principles allowed for the space to take shape quickly while being open for rearrangement in the future. Removing the pre-existing wall and built in cabinets, adding countertops, affixing pegboard, and installing glass walls produced an open rectangular space that passersby could peek into.

Discussion

The design principles of mobility, diversity, and openness guided the makerspace setup and facilitated adaptability. The principles have utility to the design of new learning spaces, including schools, libraries, and museums. They can help recognize possible inaccessibility, obstruction, immobility. and homogeneity through small and big changes, such as adding wheels to a cart. We envision spaces all across learning settings that are open and accessible at odd hours, that value a diversity of approaches, and that allow for spatial arrangement to be part of the creative learning process. This has implications for how we conceive of design of educational settings that are established in existing institutional settings as a longer-term process in which materials take on an active role in the shaping of continuous learning possibilities. This calls for practical consequences for tracking continued material design and tensions when contending assumptions of learning meet.

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