Designing Community Knowledge in Fabrication Labs: Design Directives and Initial Prototypes

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Abstract: In this poster, we present our process of designing physical and digital supports for learning and community development in fabrication labs. Recognizing mere access to technology is not sufficient to bridge the digital divide associated with technological fluency, we conducted design research and developed initial prototypes to support equitable experiences across lab members. We share three design directives for community learning supports in fabrication labs as well as our initial prototypes.

Introduction

Every few decades, a new set of skills and intellectual activities become crucial for work, conviviality, and citizenship. In the early seventies, computer programming was one of them (Papert, 1991). The educational establishment derided the idea of *programming* as a fundamental pedagogical goal, but in recent years this idea has been challenged by easier to learn programming tools and the expansion of accepted disciplinary topics in K12 to engineering, design, and computer coding (Astrachan, Hambrusch, Peckham, & Settle, 2009). In 1999, the National Research Council suggested that fluency with technology should no longer be considered merely a vocational skill or a way to train future STEM workers, but we should regard it as knowledge valuable for every citizen, a claim that resonated with the concerns of Papert (1991) and diSessa (2000) around fluency with new media.

With the invention and increased affordability of such digital fabrication tools as 3D printers and laser cutters, fabrication labs are becoming ubiquitous across settings-- in schools, in community centers, and even in museums. The analogy of digital fabrication with computer programming is clear as these new technologies are becomingly increasingly accessible and their associated skills are more highly valued. As a result, many schools are adopting such programs across the country. However, the spaces where digital fabrication takes place (fabrication labs or maker spaces) require innovation in terms of how students build knowledge together. Most of these spaces are the collection of improvised sets of tools and environments, which work well for experts but could not work for novices. As Pinkett (2000) articulates, "Access does not imply use, and use does not imply meaningful use, we must also consider the nature of engagement we seek to promote." Equity issues arise when adequate support is not available. As Blikstein (2013) demonstrated, such environments disproportionately benefit male students, learners from high-income schools, and students with parents with an engineering background. In order for a fabrication lab to thrive and support all types of students, we must build and nurture the social and cultural experience in addition to providing the equipment and physical space. In this paper, we will address the design of spaces for collaborative and project based-learning, with a particular focus on issues of equity and inclusiveness. We borrow from the sociocultural constructionism framework developed by Pinkett (2000), which emphasizes the role of community members as active change agents and knowledge producers within a learning context.

Design-based Research and Initial Prototypes

The first author conducted design research in the fabrication lab prior to having participated in the lab in any capacity. This novice's perspective, by design, allowed for insights to surface that more immersed others may not have perceived. Through observations and interviews with various lab users, including lab assistants, current graduate student lab members, high school workshop students, newcomers to the lab, and lab alumni, we developed initial directions for space design prototypes. Below, we describe the ideas that emerged from this design research and how we fashioned these insights into design directives for the lab space.

In fabrication labs, students tinker and build to discover the myriad constraints and affordances of lab materials and equipment. In the process, they adopt and adapt techniques for realizing their project visions. Observations in our fabrication lab indicated that such discoveries were primarily individual experiences and were opaque to other lab members. During open lab time, when students who did not know each other occupied the space, there were few moments of sharing and discussion. Despite this lack of interaction, when the opportunity arose, lab members were eager to share discoveries with each other. For instance, we observed a former student excitedly relaying an insight he discovered through trial and error to a student he noticed etching text into clear acrylic, which was an element of his own class project the prior year. In this case, knowledge sharing occurred due to happenstance. We viewed this as an opportunity to design ways for students to "stumble across" more knowledge sharing moments.

One might assume that lab assistants, who have the most pervasive presence in the fabrication lab space, would act as mediators of the knowledge that individual students derive from their experiences in the lab. However, we noticed that students of all experience levels approached lab assistants primarily to ask one question: Where is "x"? The second most common question type was related to general machine usage. Not only were the answers to such common questions highlighted in the equipment training materials, but these questions could be answered by any number of lab members. Again, we viewed this as an opportunity to design easy entry points for lab members to interact with each other and collaboratively find solutions. This insight, again, pointed to the need for more scaffolds to support lab member sharing and co-discovery. With these findings in mind, we generated three design directives: 1) How might we make student work more visible? 2) How might we facilitate lab member introductions? 3) How might we provide scaffolds for just in time sharing of small discoveries? As a way to test our design directives, we created digital and tangible prototypes, of various levels of resolution, with materials such as paper, cardboard, and existing tablet applications.

Hargadon and Sutton (2000) refer to the term *knowledge brokering* as a strategy that the most innovative groups adopt wherein people are able to borrow from previous ideas and repurpose them for future use – using "old ideas as the raw materials" for new ones (Hargadon & Sutton, 2000; p. 158). In the context of the fabrication lab, we view prior project work across lab members as "raw materials" to spark new ideas. In addition to providing display space for actual projects, we aimed to create a persistent digital memory of all of the projects created in the lab via tablets mounted in the space. With Twitter hashtags and visual Twitter feed applications, students are able to share photographs of their projects on Twitter, which would simultaneously be broadcast to tablets placed strategically in the space (Fig.1, left).

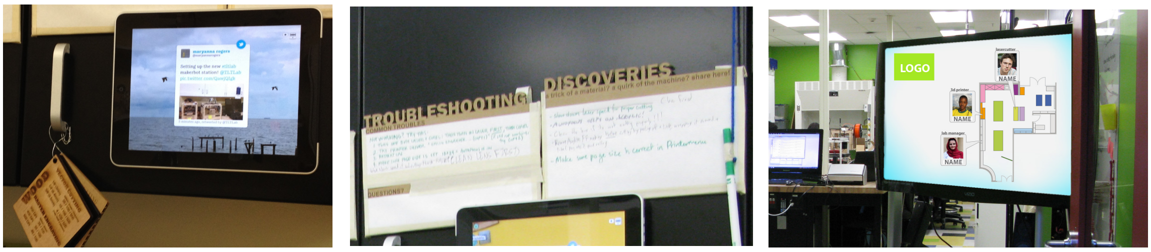

Figure 1. (left) A dynamic, visual Twitter feed creates persistent memory of what was created in the fabrication lab; (mid) a paper prototype supports just-in-time sharing of discoveries in the lab, (right) a visualization of lab members currently in the fabrication lab makes individual expertise transparent.

As noted above, we observed that lab members had been reticent to approach unknown lab members unless they were in the midst of an activity that related directly to their own experience. This lack of interaction concealed the diverse areas of expertise distributed across lab members. In response, we prototyped a dynamic visualization of individuals using the lab space (Fig. 1, right). Via an online schedule and RFID tags, which lab members use to "check in" to various stations, members entering the lab could see with a quick glance how many people were in the space, their background, and their lab expertise. Finally, in order to support just-in-time sharing of individual insights, we posted signage above the laser cutter station with heuristics for using the equipment and for sharing new discoveries about the equipment (Fig. 1, middle).

Conclusion

Through design research conducted in a collaborative fabrication lab, we derived three design directives, and created three prototypes in the collaborative space to address knowledge visibility, expertise identification, and knowledge sharing. We are continuing this work by testing the effectiveness of each component, and devising new artifacts based on our evolving research in these spaces.

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