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Makerspace for a Relocated STEM Library

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A small branch of a large academic library is in the process of relocating from one area of campus to another. Although the new space is drastically smaller than what they currently have, the librarian wishes to build upon the small maker area that was recently created for the relaxation and enjoyment of patrons. With the SCAFFOLD makerspace design framework, this new area will be created using the latest research in making and learning, keeping inclusivity at the forefront of all activities. This paper describes the current maker area, what the plans are for the new space, and how that space will be designed using this new SCAFFOLD method. It is hoped that this project can be replicated by any academic librarian wishing to add a small yet useful makerspace while staying within their budget.

Introduction

The Engineering Library at the Pennsylvania State University is preparing for a major move to another part of campus. Although our new space will not be large enough for us to bring the book collection with us, we still will have an area for students and patrons to work together and access the library's many resources. It is proposed that we use some of that space to create an informal maker area that will allow our patrons to relax and work on small non-class-related projects and activities that will help them learn the soft skills needed to become better engineers, all in a stress-free environment. To ensure that the makerspace is useful for the education of our students, it will be designed in accordance with current learning theory, utilizing the SCAFFOLD design framework.

Literature Review

Makerspaces and Education

Although "making" and creating has been a human activity since the beginning of the historical record, its use as an educational tool backed by theory is a more recent development. Dale Dougherty (2012) defined those creators not as "inventors" but "makers" – people who create for the fun of creating and learn by taking things apart and putting them back together again (p. 12). Making can fit into education as a way of allowing students to demonstrate what they have learned in the classroom and show evidence of their understanding.

For many decades, shop classes provided a way to allow students to do just this, but in the later part of the 20th century, due to both lack of funding and support, they began to be offered less and less frequently, replaced by "theoretical classes" instead (Blikstein, 2013, p. 3). However, since the turn of the century, the cost of equipment has dropped rapidly while engineering firms started complaining that graduates were no longer able to do any real design work. This led to the incorporation of makerspaces and makerlabs at many universities. These spaces can assist with:

- Enhancing existing practices and expertise
- Accelerating invention and design cycles
- Allowing for long term projects and deep collaboration between students (p. 7)

The maker movement, meanwhile, as defined by Halverson and Sheridan (2014), is "the growing number of people who are engaged in the creative production of artifacts in their daily lives and who find physical and digital forums to share their processes and products with others" (p. 496). The authors even go further to define "making" as a learning activity, "makerspaces" as designed learning environments, and "makers" as students and participants (p. 502). According to their research, a makerspace is not just a complement to classroom learning but an important learning environment itself, which allows for collaborative and constructive learning to take place far beyond what the classroom can provide. Makerspaces are informal areas, which may make assessing individual learners over time difficult. Instead, it would be best to just assess the activities themselves and the use of the space (Halverson & Sheridan, 2014).

Encouraging students to learn through play (also known as "tinkering") has become a popular reason for schools, museums, libraries, and other community institutions to create makerspaces. For tinkering to be an active context for learning, the following elements must be in place:

- Engagement – Learners should want to spend time doing the activities
- Initiative and Intentionality – Students set their own goals and accept feedback to reach them
- Social Scaffolding –Students help each other with projects and are willing to learn from the work of others
- Development of Understanding – Students can explain what they are doing and why they are doing it

Tinkering in makerspaces can help students better understand STEM topics while having fun and even encourage a few to think about careers in those fields (Bevan, Petrich, & Wilkinson, 2015).

Makerspaces and Engineering

A look at recent research in the role of makerspaces in engineering education has shown that they have become widely adopted at university engineering departments across the country (Drayton, 2019). It was found that not only do makerspaces enhance classroom lectures, but that students enjoy using the space for personal projects. Two interesting findings were that makerspaces can act as an entry point to entrepreneurship and that they "act as an informal setting for under-represented minorities and female students to explore engineering in a safe and supportive environment" (p. 6). Entrepreneurship can be supported via the use of a makerspace as a place for small-scale production and prototyping new products in an innovative environment. One researcher has gone as far as to suggest that the current maker movement will allow more people to design products, build networks, and lower the costs of initial production, all of which would influence entrepreneurship (Van Holm, 2015). However, more research is needed before those claims can be truly substantiated.

Makerspaces can be used to create safe, inclusive environments for women and other underrepresented minorities to learn how to create and participate in the engineering community. These spaces and their activities can, with proper guidance and supervision, create pathways for students to feel more comfortable and confident in their skills through legitimizing "arts and crafts" as important contributions to learning STEM. With makerspaces, "women take on new roles that help them encounter creative outlets through making and innovating. Through the makerspace, women can gain support and respect that validates the work that they are doing" (Tomko et al., 2019, p. 713). In fact, makerspaces can help underrepresented students:

- Move from outsiders to insiders and become disciplined in the makerspace area
- Learn to use the vocabularies of innovation and creativity as codes of communication
- Actively cultivate supportive making communities. (Aleman et al., 2022, p. 362)

Researchers at the University of Texas in Austin studied how often undergraduate engineering students used the College of Engineering's new makerspace and what determined return visits (Josiam et al. 2019). They found that most (two-thirds) first visited the place due to course requirements. Over 72% of those students returned to the makerspace to work on projects of their own choice outside of course requirements. This shows that students will use university makerspaces on their own if they know about them and use them for class work.

Meanwhile, a different group of UT Austin researchers studied how using makerspaces for course projects impact students' attitudes toward the space and the development of engineering design skills (Carbonell et al., 2019). They found that "technology self-efficacy, innovation orientation, affect towards design, design self-efficacy, and belonging to the makerspace were all positively and significantly impacted within individuals who completed projects in the makerspace" (p. 6). Developing all these skills is necessary for engineers to be successful in their careers. The fact that makerspaces can play a key role in teaching these skills should bode well for their future use. One surprising result of this research is that it showed how makerspaces can create a sense of belonging for students and give them confidence in their own abilities as engineers.

This means that implementing the use of makerspaces in first-year engineering curriculum is extremely important. At the New Jersey Institute of Technology (NJIT), first-year instructors have been making use of their institute's makerspace to introduce students to the product design process, research, and problem-solving (Borgaonkar, Sodhi, & Alkhoury, 2019). At the end of the course, students were asked five questions to determine the effectiveness of using the space in class. The results were overwhelmingly positive, with the researchers planning to track whether the students use the space in future semesters on their own or for more courses.

Makerspaces in Academic Libraries

Makerspaces have also become an additional service provided by academic libraries on campuses nationwide. Colegrove (2013) reminds us that libraries are more than just a support structure for solitary readers. "Today's libraries are incubators, collaboratories, the modern equivalent of the seventeenth-century coffeehouse: part information market, part knowledge warehouse, with some workshop thrown in for good measure." Makerspaces are just a newer resource that complements the activities that libraries have been providing for years.

At the University of Arizona in Tucson, a pilot facility was created to see how a library-sponsored makerspace could create a collaborative community of student makers, entrepreneurs, and digital scholars (Nichols, Melo, & Dewland, 2017). A wide range of state-of-the-art equipment was purchased and provided for use within the Science and Engineering Library, who partnered with university organizations to utilize the space. As the authors state, "libraries provide a neutral space for researchers of all different stripes to use and tinker with the equipment freely. This is especially important for disciplines with limited resources, including external funding, because it allows for students and researchers to engage in technologies that would otherwise be cost prohibitive" (p. 366). They focused on working with business and humanities students, many of whom were unable to access the technology in their own departments. This allowed them to have the same opportunities and experiences as their counterparts in STEM fields, showing that makerspaces can be successful beyond applications in science and engineering.

Assessment of Makerspaces

It is also important to assess makerspaces to ensure that they have a positive impact with users. This can be done by talking to patrons, obtaining feedback through anonymous surveys, taking photographs of activities in progress, and even taking notes while observing activities (Millerjohn, Abrahamson, & Holcomb, 2024). The data collected can be analyzed to determine whether the outcomes of activities meet the requirements set out by the original vision of the makerspace and come up with ways to improve.

One of the biggest problems with assessing makerspaces derives from the difficulty in assessing creativity. This creates a bit of tension when transferring makerspace learning to a formal classroom setting (Walan & Gericke, 2023). In fact, Halverson and Sheridan (2014) have suggested that formally assessing creativity can hinder its development for many students. Until the conflict can be resolved, it may be best for making to be a support for classroom learning, which makes libraries of all types natural places for makerspaces.

The “SCAFFOLD” Makerspace Design Framework

As makerspaces become more popular and used in a variety of settings, many educators have noticed a need for a formalized framework based on intersectionality and universal design (Seo & Richard, 2021). To meet this need, researchers from the University of Illinois and the Pennsylvania State University have collaborated to create the “SCAFFOLD” design framework, which is intended to include considerations of equity, inclusion, and accessibility in all aspects of makerspace design and use. There are eight principles to the framework: simplicity, collaboration, accessibility, flexibility, fail-safe, object-oriented, linkability, and diversity.

Simplicity

Simplicity “seeks straightforward, easy and intuitive design” (Seo & Richard, 2021, p. 804). The activities need to be easy to understand and used efficiently. They must also lower cognitive and physical barriers to a point where patrons with dis/abilities can be fully engaged in the making process while also ensuring a reduced learning curve. “Minimizing cognitive and physical fatigue in interacting with tools, environments, and activities, therefore, should be carefully taken into account in the design process” (p. 805).

Collaboration

Collaboration “connects individuals into ecological group cognition for processing, planning and sharing making projects” (Seo & Richard, 2021, p. 805). Makerspaces and activities should be designed to encourage groupwork either overtly or allow individuals to share what they are doing with others. Learners will be able to develop their own individual skills while actively sharing their ideas and learning how to navigate group social dynamics. “Hence, it is imperative for educators and learning scientists to design our learning activities and curricula in a way that provokes making ‘shared objects’ through collaborative negotiation, not just simply leaving learners to work on disconnected (i.e. nonshared) objects” (p. 806).

Accessibility

Accessibility “points out the need for multiple modalities for both input and output of objects, interactions and activities” (Seo & Richard, 2021, p. 806). This principle is closely related to inclusion and the ability to allow as many people as possible to use the makerspace. For example, many toolkits use color-coded systems and printed labels to help users create items and interact with them. However, learners with dis/abilities such as visual impairment and dyslexia may not be able to make full use of them without a more tactile display to assist them.

Flexibility

Flexibility includes dexterity (like providing a choice in methods to accomplish an activity) and adaptability, such as using height-adjustable tables (Seo & Richard, 2021). For flexibility, using customizable and/or configurable tools and environments will accommodate the largest number of users comfortably in ways that fixed designs would not. As for adaptability, different sizes of parts can be offered for the same activity, allowing users with more limited manual dexterity the same opportunities as everyone else in the space.

Fail-safe

Fail-Safe and "safety" are remarkably similar in definition. We want to ensure that both the space and the activities provided are safe to use and do not contain any hazardous parts or substances that may harm patrons. Activities should use objects and tools that are reliable and not easily broken. Particular care should be taken to ensure the safety of children and elderly patrons (Seo & Richard, 2021). We need to also ensure that the makerspace can be used by assistance technologies (like artificial limbs) without damage incurring to either the space or the patron.

Object-oriented

Object-Oriented means that "each piece of a maker kit, each environmental object and each activity component should have its own distinct purpose and functionality" (Seo & Richard, 2021, p. 809). Every component of every activity we provide must function with the rest of the activity and be organized in such a way that any patron can easily find it and interact with it.

Linkability

Linkability is "the potential for both connectable and extensible maker tools and/or practices. A maker practice that allows linkage across different concepts, tools and subjects leads to a prolific combination of creative ideas" (Seo & Richard, 2021, p. 809). Users should be able to combine different tools and activities to create their ideas. Every effort should be made to ensure that the items in the makerspace are compatible with each other.

Diversity

Diversity, for the purposes of this design framework, is the ability of the makerspace to include multiple cultures and backgrounds (Seo & Richard, 2021). When first creating the space, it would be extremely useful to involve potential users as design partners to ensure their needs are met. By including stakeholders from many different backgrounds in the design process, "we can redesign makerspaces so that learners with different physical and cognitive abilities are represented as learners and mentors, where dialogue around experiences is framed as inclusive and central to learning and where learners can work together to critique and reshape how designs meet their needs" (p. 810).

CURRENT Informal Makerspace

The Pennsylvania State University is a Carnegie Level-1 research university located in University Park, PA. The College of Engineering, officially founded in 1894, offers bachelors', masters', and doctoral degrees in 13 schools and departments. The college's current enrollment includes 8,710 undergraduate and 1,777 graduate students (Penn State, 2024).

The library system at Penn State is one of the largest in North America, with several million volumes of books and materials along with several thousand journal subscriptions (Penn State University Libraries, 2023). The library works as a partner with the college to provide learning services and support to students, faculty, and researchers. These services consist of information literacy instruction, research guidance, access to the library's collections, student and faculty engagement, and library outreach.

The current makerspace in the library is very informal and only requires the use of two tables and four chairs. The materials change monthly, with activities ranging from Legos and a button maker to a collaborative sticker-by-letter poster (see Figures 1 and 2). Students and other patrons may use the space at their own leisure, but there are no specific learning activities tied into the makerspace. The guiding principle behind its existence is to provide the library's patrons with a place where they can relieve some stress and work on something that has nothing to do with their classroom learning.

Figure 1
Button created at the Engineering Library's makerspace (Photo by Author)

Figure 2

The Engineering Library's Sticker-by-Letter Poster (Photo by Author)

In summer 2024, the library will be moving to a new permanent home on the second floor of the Engineering Collaborative Research and Education Building (ECoRE), located on the west side of the University Park campus. Although the overall space we have been given is smaller than the current library in the Hammond Building, there exists the opportunity to create a new makerspace location that is grounded in current learning theory while still providing "stress-free," relaxed activities that the students enjoy. The best location in the library for the new space would be the "quiet study room." A corner of the room can be repurposed into a new, larger makerspace, utilizing a couple activity stations that rotate out each month. The room can be locked when the library is closed, allowing for both security of the items and the capability to keep everything out instead of having to pack all items away each night. Having the makerspace close to a couple of internal windows that look out onto the main hallways will also help to market its existence to anyone who walks by.

New Makerspace

The proposed new makerspace in the library must be well-designed, with activities that enhance the educational experience of our patrons, while allowing them to have fun in the process. The design must also be inclusive enough to allow as many students as possible to participate. To this end, we have decided to create our space following the SCAFFOLD design framework using the eight principles mentioned above. We believe that this design will meet the needs of our patrons and tie our space and activities to current educational theory. This will also enable us to maintain our space as a "safe" learning environment for all our patrons, no matter their needs or the activity they choose:

- **Simplicity** – The activities we use in the current library, like the button maker and Legos sets, easily meet this requirement, as do littleBits and related circuitry tech.
- **Collaboration** – The activities we have mentioned above can be used in a collaborative nature, with the space itself set up as grouped tables and chairs rather than individual-use stations.

- **Accessibility** – A few things that we can do to meet this principle include ensuring there is enough space for wheelchairs and other mobility assistance devices, creating labels in Braille for items, and even setting up certain times of the day, if possible, for a quieter experience for those patrons who wish to avoid a sensory overload situation.
- **Flexibility** – We will allow patrons to attempt activities without having to start from a "default" setting; in fact, most of the activities we currently provide can be quickly adapted to the needs of the learners. The button maker may be a bit difficult in this respect, given the need to have enough arm strength to raise and lower the handle. Having library staff assist when needed should be enough to mitigate the issue.
- **Fail-Safe** – We will ensure that the area around our makerspace is hazard-free and easy to navigate. Any furniture pieces used will be regularly inspected to make sure that they are not damaged and remain safe to use. All activities will include all needed parts and the puzzles we set out will have all their pieces.
- **Object-Oriented** – Many current makerspace kits use color-coding to help, and I do not see any reason we could not do the same. We will also organize the space so that all items are easy to find.
- **Linkability** – Activities can be created to build upon previous ones. We can also create informational boards that explain how a certain activity complements key skills taught in the engineering curriculum.
- **Diversity** – The college is made up of students and faculty members from around the world, and the makerspace in the library should be designed with this fact in mind. One thing we can do is have activities at certain times of the year that either highlight the college's diverse population or create a product that can be linked to distinct groups (like specialized buttons utilizing the button maker). The library already has excellent working relationships with many multicultural student groups, who can be asked to help design relevant events.

Items in Makerspace

The new building that contains the library is located next to the recently opened "Learning Factory." This large space is a four-story makerspace constructed specifically for student use and includes wood and metal shops, electronics labs, a space to test out new "Internet of Things" projects, a room full of 3D printers, and a large exhibition space on the top floor. Since our patrons already have free access to all this high-tech equipment, we felt that there was no need to spend money from a shrinking budget to replicate anything found there. Instead, we decided to focus on low-tech, relatively inexpensive items and tools that would allow our patrons to relax and find some relief from the stress that builds up over the course of a busy semester.

Therefore, the items we keep on hand will focus more on general fun than on engineering skills. We will continue to allow use of our button maker for student group projects when requested. We have already begun using our sticker posters as contest prizes when they are complete, which has proven to be popular. We have a rotation of puzzles and coloring pages with pencils set out on tables for patrons to work on in their spare time. Our newly hired Engineering Librarian has even begun to bring in a sewing machine once or twice a semester to hold workshops for students who wish to learn how to repair their clothes or backpacks. The space is designed to complement the other activities in our quiet study space, not conflict with them. As time goes on, we will add and remove activities at our patrons' request.

Assessment of Makerspace

As mentioned earlier, assessment of informal makerspaces should focus more on the use of the space than on the individual student products (Halverson & Sheridan, 2014). There are a few different ways the engineering librarians and staff can evaluate the makerspace and use the information to improve it. The method we choose is to keep track of how many people are using the space, what activities are being used, and what times of day/week are the most popular. This method would allow us to determine which activities are getting the most use and when. After several months, or a full semester, we can take the gathered information and ensure that the activities and space are geared more towards what the students wish to do. We can also survey our patrons to learn what they want the space to become and work together with them to provide a fun and inclusive area for them to relax and tinker around in. Utilizing the SCAFFOLD checklist in Table 7 of Seo and Richard's (2021) article as an assessment tool will help us fill in any gaps that may form from surveys and patron counts.

Conclusion

Moving to a new location provides the library an opportunity to "start over," incorporating innovative resources and services to complement the new space. A small, informal makerspace will be an excellent addition to those resources and will hopefully provide students with more learning opportunities. By grounding the design in theory, we hope to maximize the experiences they have and encourage them to revisit our space often.

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