International Journal *of* Designs for Learning
2018 | Volume 9, Issue 1 | Pages 114-121

ACCESSIBLE MAKING: DESIGNING A MAKERSPACE FOR ACCESSIBILITY

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The purpose of makerspaces is to increase access to "making" among the general community. Because of this social justice orientation, it is important to consider how welcoming and accessible makerspaces are to individuals with diverse abilities, including individuals with disabilities. This design brief examines a three-step process used to make a university-based makerspace more accessible and welcoming to individuals with disabilities including a tour, design activity, and brainstorming session. The process helped identify simple changes that were made to the makerspace, as well as increasing student, faculty, and community access. Using a similar process, other makerspaces could improve the accessibility of their spaces, procedures, and tools.

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https://doi.org/10.14434/ijdl.v9i1.22648

INTRODUCTION

The increasing availability of tools and spaces for making has opened new frontiers in the design and customization of assistive technology for individuals with disabilities (Buehler et al., 2016; O'Kane, 2016). Empowering individuals with disabilities to design, build, and modify assistive technology can lead to greater adoption of such technology (Hurst & Tobias, 2011). While makerspaces can help increase access to technology, the accessibility of makerspaces themselves is questionable. Inaccessible makerspaces can hinder participation and inclusivity of these innovative spaces. As one of our students with a disability noted:

> *Makerspaces are often used to help build new assistive technology and increase accessibility; however, many of these spaces and tools remain inaccessible. We need to make sure disabled people can access these spaces and create the products and designs that they actually want.*

People with disabilities account for 13% of the US population (National Science Foundation, 2017). Among undergraduate students in the US, 11% report a disability (National Center for Education Statistics, 2014). Historically, the disability rights movement has used the phrase "nothing about us without us," meaning that individuals with disabilities should be included in discussions about disability, be it policy or research. People with disabilities often learn problem solving through their lived experiences and can bring innovative solutions to makerspace accessibility. As such, we sought to implement a three-step process rooted in human-centered design and universal design to improve makerspace accessibility – including (a) a tour of the space, (b) a design activity, and (c) a brainstorming session. Our goals were to identify opportunities to improve accessibility, implement simple changes, and develop resources to help others plan and design accessible makerspaces.

Human-centered design refers to close engagement of users throughout the design process. Universal design refers to making a design usable by the widest group of people with respect to ability and other characteristics (Center for Universal Design, n.d.). We sought the consultation and engagement of individuals with a variety of disabilities to both participate in makerspace activities and assess the environment and tools to create a more inclusive space for all.

THE CONTEXT

At the University of Washington (UW), we have included people with disabilities in early design discussions for a variety of new spaces. Doing so has led to spaces that are more usable rather than following the minimum accessibility laid out by ADA guidelines. We sought to evaluate how employing similar methods could improve makerspaces, which are being built in many communities (Morocz, et al 2015; Daley & Child 2015).

The CoMotion Makerspace at UW was interested in collaborating to assess the accessibility of their makerspace. The mission of the CoMotion Makerspace is "to be the collaborative hub for expanding the societal impact of the UW community by delivering the tools and connections that UW researchers and students need to accelerate the impact of their innovations." The makerspace provides access to equipment, training, and space to enable community members to turn ideas into reality in a social, collaborative environment (CoMotion, 2016).

A core tenant of the makerspace is to be "community-centered and diverse: a social place for people with different skills and common interests to collaborate and learn from each other." As such, the makerspace aims to serve all community members at UW, regardless of department, background, or ability. Given the university's commitment to inclusive communities, the CoMotion Makerspace recognized the importance of evaluating and iteratively improving accessibility of this space.

Through a partnership between the CoMotion Makerspace and the DO-IT (Disabilities, Opportunities, Internetworking, and Technology) Scholars Program at UW, we implemented the process outlined below. The DO-IT Scholars program brings over forty high school and new college students with disabilities to live on the UW campus each summer for two weeks, where they learn about future career paths and strategies for navigating college life. These students also develop skills that help them analyze space accessibility, implement principles of universal design, and advocate for resources to help them succeed in college and beyond. This partnership

FIGURE 1. Evaluation of the CoMotion Makerspace included a tour (top), a design activity in which participants worked in teams to design a wallet (middle, credit: Dennis Wise/University of Washington), and a brainstorming session to identify opportunities and challenges in creating accessible makerspaces (bottom).

provided an ideal environment to critically evaluate makerspace accessibility.

THE PROCESS

To evaluate the makerspace, we used a three-step process involving a tour, design activity, and brainstorming session (see Figure 1). The process was designed to help students understand the purpose of a makerspace, participate in design activities that makers might engage in, learn about the human-centered design process, and allow time for conversation about accessibility. Participating in the first two activities gave students the background to reflect on a particular experience within a context of human-centered design and have a rich discussion about accessibility in makerspaces.

We worked with six students with disabilities who had participated in the DO-IT Scholars Program for three years. These students were selected due to their depth of experience in leadership activities and evaluating accessibility from their prior DO-IT participation. The students had a range of disabilities - including mobility impairments, visual impairments, and autism spectrum disorders - and were interested in pursuing a variety of science, technology, engineering, and math fields in college. Engineering faculty, disability experts, makerspace staff, and able-bodied engineering undergraduates also participated in all activities.

We decided to start with the tour, since the majority of participants never had seen or used a makerspace before. During the tour, makerspace staff introduced the space, tools, resources, training methods, and safety procedures. Students were briefed before the tour to focus on accessibility and were encouraged to explore the space and ask questions.

Since many of the students did not have experience with the design process and making, everyone participated in a two-hour design activity. Our goal was to introduce students to human-centered design including needs finding, needs definition, ideation, and iterative prototyping. By going through this process, the participants had a chance to use tools and resources in the makerspace, including whiteboards, team meeting areas, and prototyping supplies while also considering the accessibility of the design process. We used a modified version of "The Wallet Project" activity created by Stanford's Hasso Plattner Institute of Design, or d.school (Both, 2016). In this activity, teams of students interview a user to learn more about their "wallet-preferences," develop a point of view statement (*e.g.,* need statement), brainstorm solutions, build prototypes, receive user feedback, and iterate. It is a fast-paced introduction to the human-centered design process. We modified the worksheets provided on the project's website to increase font size and sketching areas so that they were usable by all participants based on universal design and accommodations that students had requested.

After completing the design activity, the students returned on a second day to reflect on their experiences and brainstorm opportunities and challenges for accessible makerspaces. Space between the activities meant students had time to process the experience and returned with fresh eyes and energy. Individually and as a group, they were asked to reflect on these questions:

- What are the most accessible features of this space?
- How might we improve this space?
- What are two things you would tell someone who was creating a makerspace to maximize accessibility?

Throughout their visits to the makerspace, students, engineering faculty, disability experts, and makerspace staff engaged in conversation about universal design and accessibility. These discussions highlighted things that were done well within the CoMotion Makerspace, as well as areas for improvement.

OBSERVATIONS

Makerspace Tour

During the tour, there was a lot of excitement and curiosity about the space and tools. "Can freshmen use this space?" was a common question, demonstrating the students' enthusiasm. Students also expressed excitement about the accessibility of makerspace tools. While some students had previously not considered themselves "builders" due to visual or physical impairments, they were excited about how many of the tools, like 3D-printers and laser cutters, were computer-controlled and easily accessible to a wide range of abilities.

Touring with a group with diverse abilities also highlighted some of the competing priorities in designing an accessible space. For example, one student noted, "I really like that almost everything is on wheels, because as a person in a wheelchair it's a lot easier to get something out of your way." Furniture on wheels made it easier for her to navigate the space and customize the space to her needs. However, a student with a visual impairment voiced that she found the wheeled furniture a bit concerning: "With a visual impairment, I create mental maps to navigate spaces. I love that all of the furniture is on wheels to create flexibility, but I also like that a lot of the tools are in fixed spots. I will always know the location of the 3-D printer and laser cutter, even if the space in between changes from day to day." Similar competing priorities were evident in students' feedback about suspended electrical outlets (see Figure 2).

Safety and training were also common themes discussed during the tour. Students highlighted the need for large,

FIGURE 2. These suspended electrical outlets that keep wires off the floor prevent tripping hazards, improve wheelchair accessibility, and allow for flexibility in the space. At the wrong height (and unfortunately as experienced by one of our participants), they can pose problems for people with vision impairments. As an example of a simple change, the CoMotion Makerspace was easily able to reconfigure the location and height of these outlets to maximize access and safety. Credit: Dennis Wise/ University of Washington

high-contrast safety signs and instructions. While the makerspace had extensive training available for users, students recommended that the training materials and reminder sheets about how to use equipment be available in multiple forms (*e.g.,* electronic PDF for an individual using a screen reader). They also recommended that it should be clear how to request accommodations or assistance.

Design Activity

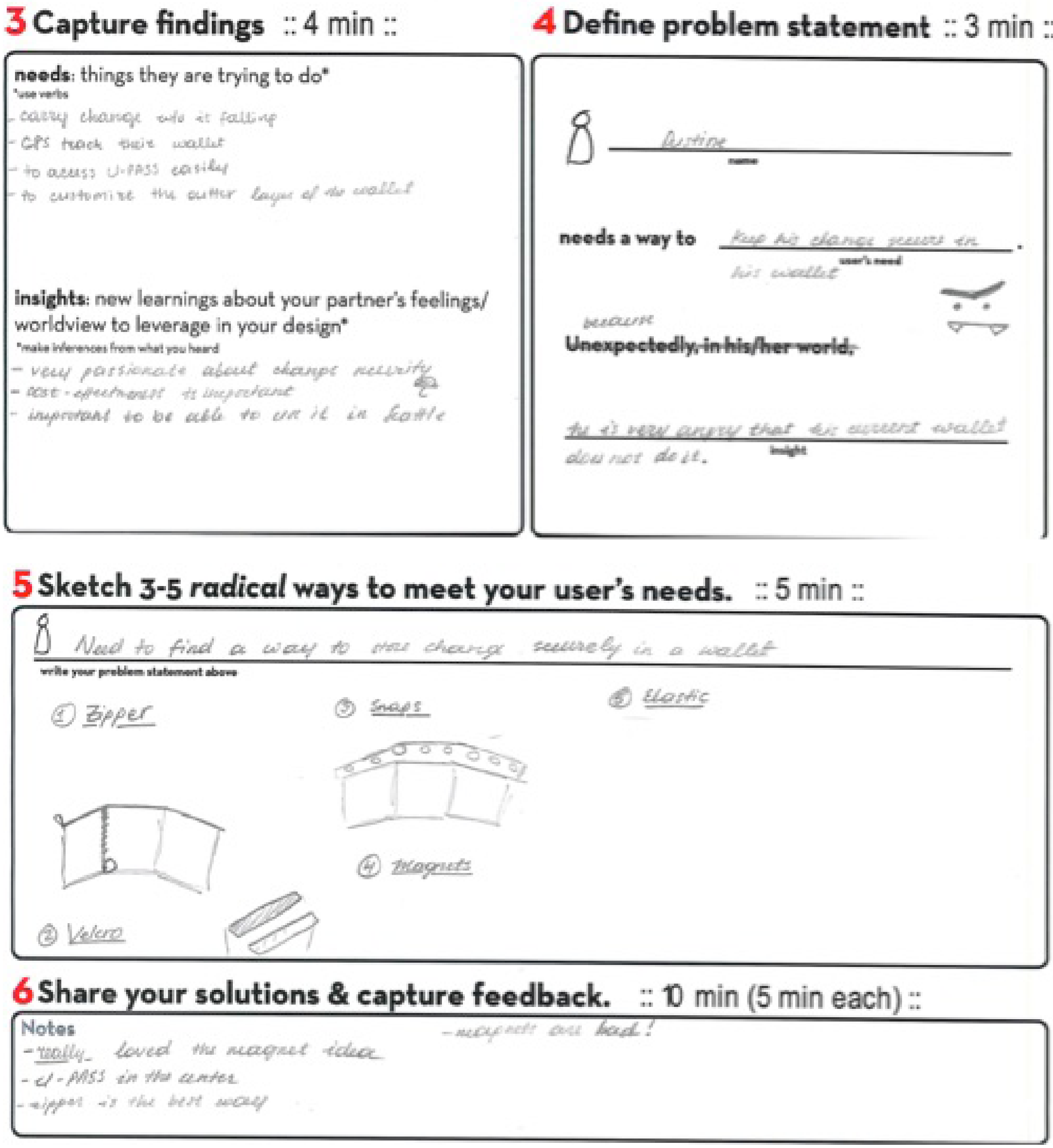
After the tour, the wallet design activity let participants get their hands dirty and learn about design. Although the activity was originally designed for pairs, we found that it was helpful to have the students work in larger teams (3 – 4) and pick one member of the team to interview as the prospective user. This allowed teams to follow the human-centered design process, but also recognized that teamwork can help overcome challenges faced by various impairments during the design process. Teams with diverse abilities were able to share areas where they could contribute and work together to interview, brainstorm, and prototype. The facilitators used the worksheets (see Figure 3) and brief introductions for each phase of the design process to scaffold the activity; both introducing the students to design while reminding them to think about accessibility and improvements to the makerspace.

In preparing for the design activity, based upon our prior experiences working with students with disabilities, we also provided a wide variety of materials to create prototypes to ensure individuals with a variety of disabilities would find materials that they were comfortable working with. During the design activity, we observed that different teams gravitated to different tools and materials. While some teams preferred highly tactile materials (*e.g.,* clay, pipe cleaners, or cardboard) other groups preferred making detailed sketches or prototypes that illustrated how the wallet could be used. All teams successfully prototyped unique solutions that addressed current challenges with wallets in daily life (see Figure 4).

Makerspace Recommendations

During the second visit, students brainstormed potential improvements to the space and opportunities for maximizing makerspace accessibility (see Figure 5). Participating in the design activity also meant they had practice brainstorming before focusing on the larger issue, as well as a chance to think about their needs and preferences in the design process. Students made recommendations based on their experiences in the particular space as well as their experiences with accessible spaces elsewhere.

The students highlighted many positive aspects of the space including the wide entrance and aisles, diversity of equipment, and easy re-configurability of the space. Ideas for improving the space included new tools (*e.g.,* a wish list), whiteboards available at multiple heights and angles, information on how to get accommodations, more labels


3 Capture findings :: 4 min ::

needs: things they are trying to do*
*use verbs
- carry change w/o it falling
- GPS track their wallet
- to access U-PASS easily
- to customize the outer layer of the wallet

insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard
- very passionate about change security
- cost-effectiveness is important
- important to be able to use it in Seattle

4 Define problem statement :: 3 min ::

Justine
name

needs a way to keep his change secure in his wallet.
user's need

because
~~Unexpectedly, in his/her world,~~

he is very angry that his current wallet does not do it.
insight

5 Sketch 3-5 *radical* ways to meet your user's needs. :: 5 min ::

Need to find a way to store change securely in a wallet
write your problem statement above

① Zipper
③ Snaps
⑤ Elastic
④ Magnets
② Velcro

6 Share your solutions & capture feedback. :: 10 min (5 min each) ::

Notes
- really loved the magnet idea
- U-PASS in the center
- zipper is the best way
- magnets are bad!

FIGURE 3. The worksheets from Stanford's Wallet Project (Both, 2016) were used to scaffold the design activity and allow the students to use the space. Students worked in teams to define the problem statement, brainstorm ideas, and use prototyping supplies to create a physical object for feedback and design improvements.

FIGURE 4. Students had access to a variety of prototyping supplies such as cardboard, duct tape, clay, and rubber bands to create physical versions of their ideal wallet. The groups had a diverse array of needs and solutions to this simple design challenge.

(including tactile and Braille options), screen magnifiers, wheels on the furniture that were easier to lock/unlock, and clear information on where common tools were located within the space. The students emphasized that although these spaces should encourage flexibility and creativity, that organization and safety were a critical cornerstone. Many students felt they would only independently use a space that was well organized, with clear procedures for safety, accommodations, and training. See Table 1 for a sub-set of the students' comments and recommendations.

Some of the recommendations are more expensive than others. Considering accessibility in the planning stages of a new makerspace can be less expensive than retrofitting existing spaces. As a space evolves, accessibility can be taken into consideration with new purchases. There are also creative solutions - like using existing tools to make better signage (e.g., a laser cutter for high-contrast signs), or as one participant recommended:

> *Consider hosting a workshop or other event to welcome individuals with disabilities to come and learn more about the space. You could even have a hackathon where participants work together to increase the accessibility and design of your makerspace.*

CONCLUSION

Information collected during these activities was reviewed and summarized by our team. In partnership with CoMotion, we created a list of easy-to-implement recommendations for increasing accessibility, which were completed before the beginning of the new school year, and a wish list for future improvements and new spaces. Examples of the implemented improvements included adding adjustable height workbenches, raising the height of hanging electrical outlets,

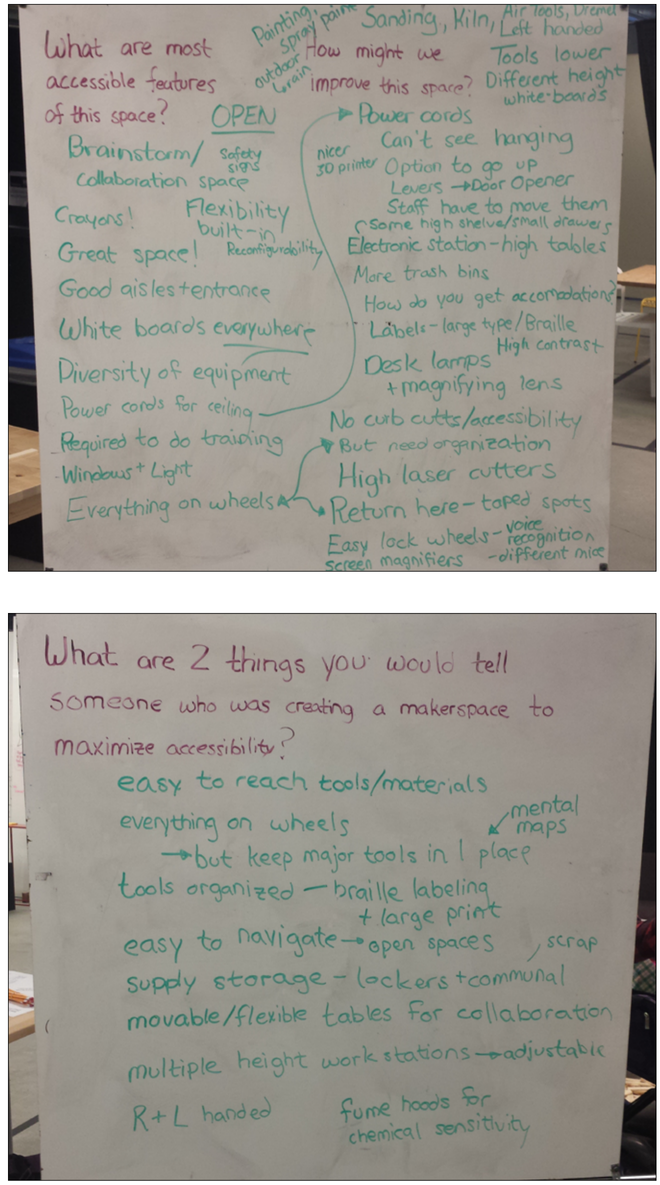


FIGURE 5. The students brainstormed many ways to improve the accessibility of the CoMotion Makerspace and recommendations for optimizing makerspace accessibility.

providing more magnifiers and desk lamps, and creating a variety of new safety signs and equipment labels. Some suggestions on the wish list may be tackled in future years; others may not be addressed.

Our three-step process combining a tour, design activity, and brainstorm with a group with diverse abilities provided a powerful and easy-to-implement model for evaluating the accessibility of this makerspace and recommending future improvements. Including students with a variety of disabilities to evaluate the accessibility of makerspaces led to a rich discussion and enabled conversation about conflicting needs to determine what might work best for the widest

RECOMMENDATIONS
Planning and Policies
• Include people with a variety of disabilities in the planning and setup of the makerspace. • Provide information on your website and orientation materials about how to suggest new equipment or request accommodations or adaptations to existing equipment.
Space and Furniture
• Provide multiple options for team and meeting space, including quiet space that groups or individuals can use; spaces that are navigable by users with wheelchairs, crutches, or telepresence robots; and brainstorming spaces that are accessible from a seated height. • Place high-contrast, large-print signs throughout the space, especially for safety information. • Provide magnifying lenses and desk lamps.
Tools and Equipment
• Keep tools and equipment in designated areas and ensure they can be reached from a seated position.
Staff, Safety, and Training
• Develop safety procedures for students with hearing, visual, or mobility impairments. • Train staff to assist and provide accommodations for individuals with diverse abilities.
Focus Groups and User Testing
• Encourage makers to consider universal design and reach out to users who are diverse with respect to disability, age, gender, race, and other characteristics. • Make universal design and accessibility a part of your culture.

TABLE 1. Sample Recommendations for Accessible Makerspaces.

group of users, further promoting principles of universal design. This design process also broadened the perspective of many of the students to potentially consider careers in engineering. Many of the students noted that the accessibility of new tools makes it easier for individuals with diverse abilities to create in flexible formats and build physical prototypes. While we were examining the makerspace, the students also noted challenges in the accessibility of the traditional design process. Many of the traditional steps in the design process, such as brainstorming on a white board and prototyping, need to be re-imagined to enable full engagement of individuals with diverse abilities.

In replicating this activity, we would make a few changes. We were lucky that users were in the makerspace during the tour and willing to discuss their projects. In a future iteration, we would pre-arrange to have a wider spectrum of users participate in the tour and demonstrate how they're using equipment. While the wallet activity provided an easy-to-implement activity that both introduced human-centered design and allowed participants to use the low-resolution prototyping tools in the space, reimagining additional design activities that took advantage of the wider spectrum of tools available in the makerspace would also broaden the recommendations for improvement. Students were talkative and had great ideas during the reflection. Because of their participation in the DO-IT Scholars Program, these students had prior experience engaging in such activities and were comfortable discussing disability with one another. With other groups of students, it may be necessary to help them develop trust with one another and familiarity with accessibility recommendations.

We have summarized the recommendations from this design case in an online document and checklist entitled *Making a Makerspace? Guidelines for Accessibility and Universal Design* (AccessEngineering, 2015). Although the recommendations do not solve every accessibility issue (*e.g.*, accessible interfaces for large equipment), they have been well received within our community. This checklist represents a living document where we will continue to monitor use and accessibility of the space and tweak our recommendations based on future feedback and observations.

We encourage others to consult these recommendations, invite people with disabilities to participate in similar activities, and test a similar process in their own makerspaces to increase accessibility and inclusivity. Implementing a similar process in your own makerspace will result in customized recommendations that may differ from our general recommendations. As one of the students reminded our team:

Makerspaces are about community. We need to ensure everyone from the community can participate.

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant EEC-1444961.

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