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Investigating the Impact of a 3D Modeling and Printing Workshop Designed for Blind and Low-Vision Students [Traditional Research Paper]

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1 Introduction

While Science, Technology, Engineering and Mathematics (STEM) courses remain a popular option for high school students, researchers suggest that students with disabilities are often underrepresented within these classes [1]. Challenges include but are not limited to the following: low expectations for students with disabilities, limited exposure to prerequisite courses, lack of role models and skilled instructors, and lack of access to individualized support [1]. Spatial ability is also thought to be a valuable skill to support acquisition of STEM knowledge, putting students who are blind or low-vision at a significant disadvantage to their sighted peers [2], [3].

In order to increase equity and opportunity for students who are blind or low-vision, interventions have been developed to support development of both STEM and non-STEM skills, including stronger collaboration between general and special education teachers [4], [5], and deploying new technologies to make complex content accessible through audio or tactile means [5], [6]. More recent initiatives include targeted workshops to support skill development and knowledge acquisition [7], and mentorship organized through community organizations [8]. Community organizations are beginning to partner with universities to offer the expertise needed in STEM fields, particularly in engineering. These include training workshops for STEM development and to help develop soft skills.

In this paper, we describe a workshop organized as part of a partnership between the Blind Industries and Services of Maryland (BISM) and the University of Maryland Baltimore County (UMBC). A four-day workshop was designed to teach skills relating to design thinking, the engineering process, and 3D printing. The workshop was targeted to the needs and abilities of high school students who are blind or low-vision. We describe the structure and outcomes from each of the sessions, and identify the lessons learned from running the workshop. Our findings offer insight into activities that were successful, changes we would recommend for future iterations, and various aspects to be mindful of in the design and development of similar workshops.

2 Related Work

2.1 3D Printing Education

With regards to 3D printing education, the accessibility of 3D modeling and printing in schools depends on a combination of challenges such as the availability of equipment, and teacher and student confidence [9]. Many teachers remain unaware of their schools' access to 3D printing resources [9]. Furthermore, it has been found that confidence plays a major role in whether educators want to integrate these tools into the curriculum, even if they know they are available [9]. However, it has also been found that community groups and professional networks can help close this gap by encouraging knowledge-sharing and experimentation [9].

The benefits of integrating 3D modeling and printing into education are evident in several studies. For example, Klement and Bártek [10] found that nearly half of the primary school students surveyed (49.5 %) were interested in learning 3D modeling to create their own designs. Their research shows that when implemented effectively, 3D modeling positively influences learning by promoting engagement and creativity. Similarly, it has been revealed that a strong positive relationship between using 3D printing and students' enthusiasm toward STEM subjects exists [11]. This kind of interactive learning helps bridge the gap between lecture and real-life application, making lessons more meaningful.

Current practices to teach 3D printing vary widely. A study on teachers in Korea found that many educators needed over a year with 3D printing software before feeling confident enough to teach it to students [12]. Software such as TinkerCAD, 123D Design, and Sketchup were mostly commonly used, though teachers noted that most 3D modeling software has a steep learning curve for beginners. Teachers emphasized the importance of teaching 3D forms, such as spheres and cubes, so that their students are able to understand foundational 3D concepts prior to attempting to design independently. Teachers often demonstrated how to model simple objects, and then assigned introductory projects like stamps, keychains, or pencil holders [12], as these tasks would help provide students with the building blocks to move to more complex designs.

For purposes of 3D printing in special education environments, researchers have asked students to work with tools such as TinkerCAD, and encouraged them to explore Thingiverse to utilize or strengthen existing designs [13]. Instructors noted that when students became frustrated with the interface, their motivation decreased [13]. Students also struggled with understanding the capabilities of the printer, for example, positioning an object on the build plate incorrectly, which resulted in printer failures. Overall, many students in this special education setting enjoyed using Thingiverse and CAD tools [13].

2.2 Community Engagement and 3D Printing

Community engagement has been shown to deepen engineering and design learning by providing participants with opportunities to interact directly with real users and problems encountered from lived experiences [14], [15]. Such partnerships help learners develop empathy, contextual awareness, and communication skills [16]. Within these approaches, 3D printing has emerged as a particularly effective medium due to its accessibility, rapid iteration, and capacity to support hands-on participation across a range of learners [17]-[19]. Studies have demonstrated that 3D printing activities can broaden participation in STEM, particularly for underrepresented students, by enabling tangible creation, collaborative problem-solving, and iterative exploration [20], [21]. Additional work highlights mobile and distributed making platforms, such as traveling makerspaces that bring 3D printers into classrooms and community spaces [21], and campus-wide fabrication centers that support service learning and community partnerships across disciplines [22], [23]. These have been proven to further reduce participation barriers and increase familiarity, interest, and self-efficacy among students from diverse disciplinary backgrounds.

3D printing has also played a significant role among disabled communities through the co-creation of do-it-yourself assistive technologies (DIY-AT) [24]-[26]. Research on collaboration and partnerships shows that multi-stakeholder ecosystems, linking universities, state agencies, clinicians, makers, and end-users, can produce personalized, low-cost technologies. These partnerships also strengthen trust, design capacity, and agency for participants [27]. University and government collaborations have also demonstrated the potential to scale DIY-AT production and deepen recipients' awareness of assistive technologies [24]. Complementary work in university makerspaces highlights how DIY-AT co-design can advance social justice-aligned practices by providing spaces for students with disabilities to address accessibility barriers and participate in institutional change efforts through design [28], [29]. Community-engaged 3D printing is a valuable foundation for inclusive learning, co-creation, and capacity-building—principles that inform the design of accessible making experiences.

2.3 Individuals who are Blind or Low-Vision and 3D Printing

With the rise of 3D modeling, information that was previously communicated with visuals and graphics can be conveyed with 3D models in a tactile form [30], [31]. For example, models of campus maps and buildings can be transformed into 3D tactile maps [30]. These 3D maps provide a tactile layout of the area and allow individuals who are blind or low-vision to understand and orient themselves in a new location. Different tactile features represent the buildings, streets, and sidewalks. The use of 3D modeling is also being applied to educational materials such as scientific models of atoms and chemical structures [31]. These 3D models of atoms and chemical structures provide students who are blind or low-vision a new way to understand and learn subject matter. Another application of 3D modeling is the use of tactile art. The use of 3D printing to make visual and graphical information tactile is important for communicating resources for individuals who are blind or low-vision [32]. For example, many children's books contain highly visual elements, but are typically inaccessible to children who are blind or low-vision [33]. The use of 3D modeling and 3D printing can transform these visual elements into tactile art to support accessibility and augment the subjective interaction experience.

While there are many perceived uses of 3D modeling and 3D printing, it is important to also consider the accessibility of the software required to create these models. The majority of 3D modeling software and 3D printing interfaces rely on visual cues and interactions [34], [35]. The reliance on visual cues makes it significantly more difficult for individuals who are blind or low-vision to independently create 3D models and 3D prints. In addition to the technical software and interface challenges, changes must be made to the educational practices around introducing 3D modeling and 3D printing to new people. Shifts in the instructional materials and the language used when teaching 3D modeling and 3D printing must be made in order for it to be more accessible [28], [35]. A need has been identified to better support individuals who are blind or low-vision when learning about 3D modeling and printing, and to identify the strategies or workarounds that can be designed to implement in a design-related course.

3 Methods

A four-day workshop was designed with the goal of introducing 3D modeling and 3D printing to high-school students who are blind or low-vision. The workshop consisted of various sessions and activities, as well as projects to engage students in learning about engineering. Each day had a morning and afternoon session which lasted roughly three hours each with an hour lunch break. Participants were recruited through our community partners at BISM. BISM runs the STAR Summer Program; a summer camp that exposes high-school students to various career fields [8]. The approved Institutional Review Board (IRB) protocol consisted of observations, interviews, and focus group discussion sessions that took place throughout the workshop. Instructors and students aged over 18 were asked to sign consent forms, while students under 18 also required consent from parents/caregivers. The following sections describe the primary goals and activities of each day of the workshop.

3.1 Participants

Participants of the study consisted of eight students who were blind or low-vision, one instructor who was sighted, and between five and eight adult staffers with a mix of available vision (Table 1). The students were the primary participants in the workshop and engaged in the various activities. The instructor was recruited through past involvement in similar 3D modeling workshops for students who are blind or low-vision. The staffers were provided by the community partner (BISM), and were there as mentors and support for the students. Very few of the participants had any previous exposure to engineering or 3D modeling and some had limited computer exposure as well. There was a wide range of available vision, technical skills, and overall interest from all participants, which contributed to a unique workshop environment.

In addition to the participants of the study, between two and six researchers were present at different points in the workshop. The researchers comprised of a mix of high school, undergraduate, and graduate students, as well as faculty members. The researchers had a range of exposure to 3D modeling and 3D printing (from limited experience to over ten years of experience).

Table 1: Participant Demographics

	Sighted	Blind or Low-Vision	Prior 3D Printing Experience
Students	0	8	2
Staffers and Instructor	2	7	2
Researchers	6	0	4

3.2 Workshop Design

3.2.1 Day 1: Introduction to Engineering and CAD

The primary goals were to introduce students to 3D printed objects, explain the basics of the engineering design process, and explore a design tool such as TinkerCAD to create different 3D models which could be printed later on. The first hands-on activity of the day involved students exploring 3D printed assistive devices (e.g. money brailler, bottle opener, can handle etc.) to try to identify the purpose of each device. This encouraged creative conversation and developed vocabulary for describing 3D printed objects. After the introduction to 3D printed objects, students were presented with a 3D printed puzzle with several design features that were used to describe the engineering process and changes in a design to improve the product (e.g. adding braille to existing puzzles). Students were then handed different puzzle cube pieces and copied the pieces using wooden blocks before moving to TinkerCAD where they were asked to replicate the puzzle cube pieces in the software.

3.2.2 Day 2: Engineering Careers and Tactile Art

The second day focused on exploring careers in engineering, as well as different applications of 3D modeling and 3D printing. First, students met with a blind entrepreneur who has a background in engineering and were able to ask about his experiences and career. The goal of this session was to demonstrate to the students that a career in engineering as an individual who was blind or low-vision is possible. Next, the students learned about the different components of a 3D printer and were able to touch and interact with one. During this session Play-Doh extruders were used to demonstrate the process of additive manufacturing, as this offered a tangible method to help learn through tactile means. After the printer exploration, students were assigned teams and participated in a marshmallow challenge where they attempted to build the tallest tower out of spaghetti strands and marshmallows. The goal of this activity was to inspire design thinking and teamworking skills by learning through mistakes. Students then learned about tactile art and different applications of 3D modeling and 3D printing. This session provided a different perspective on 3D printing in comparison to engineering. The goal of this session was to encourage excitement about 3D printing outside of an engineering context. The second day ended by introducing the 3D modeling projects to the students and allowing them time to brainstorm ideas for their projects which they would complete over the remainder of the workshop. There were two projects the students were asked to focus on; a cane identifier for their white canes and a luggage identifier for their suitcases. Both of these projects were selected because they were practical objects the students could use in their lives while also having a creative design element. Tactile identifiers support individuals who are blind or low-vision in differentiating their cane or suitcase from others.

3.2.3 Days 3 and 4: 3D Modeling Project

The structure of the third and fourth days were similar to each other, enabling students to brainstorm and prototype ideas for their projects. Students were moving at different paces and had access to all the prototyping materials, as well as the computers to complete 3D models. 3D model prototypes were printed overnight to allow for changes and iterations to be made on the fourth day. Final design prints were completed after the workshop and distributed to students after a few weeks. The last day of the workshop ended with a discussion amongst the students about their experiences with the software and design process, what they learned, and what they are excited about. One-on-one interviews were also conducted at the end of the fourth day with the adult mentors and staffers to understand their perspective throughout the entire week. Mentors were asked about different aspects of the workshop such as the teaching methods used, relevance of the projects, interactions between presenters and students, and more. All of this information was thought to be valuable to collect, in order to support the development of future workshops.

3.3 Data Collection and Analysis

Observational notes, recordings, and photos were taken each day by at least two researchers from the research team that focused on the reactions and interactions of the students throughout each activity. Each researcher underwent training to understand best practices when taking observational notes prior to the workshop. The observational notes were organized based on the specific activity and included information such as the types of questions students asked, the way the mentors supported the students, and different discussions about the activity between students. All of these were designed to understand the impact and how the students felt about each activity. Similarly, the recordings and photos were collected to supplement the observational notes, and to further document results and interactions between participants.

After the completion of the workshop, the notes were collected, transcribed, and inductively analyzed for relevant quotes and observations by six researchers. Analysis was completed inductively, meaning no previous themes were used to guide the analysis. Researchers met after the analysis to discuss the major themes arising from the data [36]. The following sections first identify the major findings from each activity or session before discussing primary themes from the overall workshop.

4 Findings

4.1 Introduction to Engineering and Self-Confidence

The first day of the workshop was primarily focused on an introduction to engineering and exploration of the possibilities of 3D printing. Activities were met with a range of reactions and levels of engagement. Students were handed various 3D printed assistive technologies and were instructed to guess the purpose of each device. Some students showed a lack of confidence in exploration activities and quickly gave up guessing or requested help/advice from mentors, whereas other students were curious and interested in trying out the device in different ways. This became a consistent theme throughout the workshop, a contrast of levels of engagement based on levels of self-confidence.

The second major activity focused on understanding 3D modeling and encouraged the students to take existing shapes and replicate them using blocks. This activity was meant to teach the students about 3D modeling as a transitional activity to interacting with the computers. Similar to the 3D printed assistive technology activity, there were different reactions to this activity. Students who were engaged and curious about the first activity quickly jumped into trying to make the existing puzzle cube shapes. Other students, in comparison, were concerned about making a mistake and elected not to participate. Overall, students gradually became more interested throughout the activity as the initial uncertainty lessened.

4.2 The Impact of Self-Doubt on CAD Modeling

The second half of the first day of the workshop introduced students to computers and 3D modeling using TinkerCAD. Similar initial reactions were observed at the beginning of the day with the 3D printed assistive technology. Many students expressed frustration and self-doubt, saying they could not complete certain tasks because of limited functional vision being available to them, “I can’t do this with no vision.” The concerns for making mistakes and lack of self-confidence were evident as the students started working with the computers. Mentors and staffers realized that positive feedback and showing genuine interest in the student’s product eased the concerns and supported self-confidence. By the end of the first day, there was a noticeable positive shift in interest in 3D modeling and increased levels of self-confidence. Students were more actively asking questions about 3D printing and the ways that it could be applied outside of the workshop.

4.3 Importance of Mentors in Engineering who are Blind

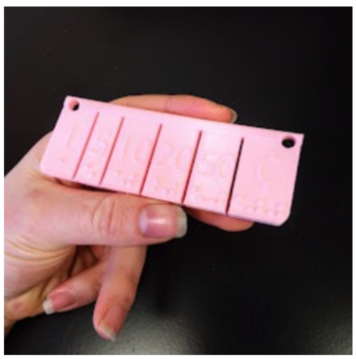
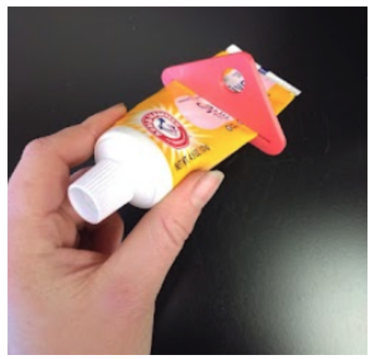
On the second day of the workshop, students were introduced to an entrepreneur with an engineering background who was blind. The purpose of this session was to demonstrate to the students that they are more capable than they might think, and that careers in STEM are possible even if there are challenges which need to be navigated. Speaking to another person who was blind and being able to understand his experiences supported their self-confidence in potentially pursuing a career in engineering. Students were present and active, asking questions not only about the panelist’s professional experiences but also about broader issues of accessibility and identity in the workplace. Questions such as “How does it feel to be visually impaired?” and “What if you meet someone who is doing the same job as you?” reflected students’ curiosity about what it means to pursue engineering while navigating vision loss.

4.4 Tactile 3D Printer Interactions

Following the panel, students interacted with a 3D printer to learn about the different components and operations. Multiple 3D printers were brought out for students to touch and explore. Students were guided to the location of the nozzle, print bed, and other parts so they could understand the layout of the 3D printer. After exploring the 3D printers, students were able to use Play-Doh extruders to understand how filament goes through the nozzle to create the 3D prints. This was thought to help them better conceptualize the process when working with a real 3D printer. This activity demonstrated a significant amount of curiosity from the students which was a shift from the first day. For example, students expressed interest in the differences between each of the 3D printers and how the parts worked together.

4.5 Creative Engagement Through Tactile Art

During the second half of the day, students transitioned into the tactile art portion of the workshop. Students explored a range of 3D printed objects, including assistive devices and magnetic puzzles, and later used LEGO bricks to construct their own creative designs. Some students initially expressed hesitation about engaging in artmaking because of their limited vision, but tactile interaction gradually increased their levels of comfort and enthusiasm. As they handled the 3D printed pieces, students were able to describe design ideas which could benefit from being 3D printed, such as puzzles based on familiar pictures, and speculated about the purposes of the assistive devices. Some students were able to correctly identify the devices, such as the paper money brailler (Figure 1), while others were surprised to learn the function of the devices, such as the toothpaste squeezer (Figure 2). The LEGO activity further encouraged creativity and self-expression; students built structures ranging from buildings and staircases to abstract forms and figures representing their favorite social media influencers. Throughout these activities, mentors, and volunteers provided guidance and conversation to sustain focus and support students who struggled with design ideas or attention. Students who initially doubted their ability to create art began to express growing confidence through tactile building. Students who already identified as artistic expressed strong enthusiasm, “I really like art, so I really like this [activity].”

Figures 1 and 2: Paper Money Brailler and Toothpaste Squeezer

4.6 Personalizable 3D Modeling Projects

The last two days of the workshop were focused on working independently on their modeling projects. On the third day, students were observed to be nervous initially worrying about the process of 3D modeling. Concerns included the accessibility of the 3D modeling software, TinkerCAD, as well as issues with navigating and extracting files from Thingiverse. While the majority of students had some functional vision available to them where an assistive device such as a magnifier could be used, for students who relied on a screen reader, challenges were expressed regarding how to work with such a visually-focused tool. As individuals became more accustomed to the software, their overall levels of confidence and excitement increased. Participants were excited to search for designs related to personal hobbies or interests including animals, online influencers, cars, music, and more. Some individuals even used photos as references and created their own models. Individuals also grew excited about modifying existing models by changing the size, shape, and colors within TinkerCAD. While many individuals did not interact with the provided physical prototyping materials, all participants developed multiple 3D models that addressed the project goals. By the end of the third day, students were excited to continue working on their 3D models the next day and explore even more features of the software.

The fourth day started in the computer lab as students continued to work on their projects. Individuals were satisfied with the progress and products they had created by the completion of the morning session, and were no longer interested in editing their designs. In the afternoon, the organizers had to change the agenda in response. Individuals participated in white cane practice and reflected on their experience throughout the week. Participants remarked about the importance of asking for help and learning strategies to take care of themselves when stressed or upset about something. These were important skills participants developed as they hit roadblocks with their projects. Some of the specific skills mentioned include taking a walk around the hall, drinking water, or even breathing when frustrated. Many participants expressed having enjoyed their time learning about 3D modeling and 3D printing and an interest in continuing to work on TinkerCAD to make new models. Students also remarked about their "superpower" of curiosity that supported them in learning new things without fear and continuing to ask questions.

5 Discussion

5.1 Engagement and Successfully Implemented Components

Overall, students were observed to be more engaged when conducting hands-on activities rather than during lectures and discussions. When students anticipated a hands-on activity, their focus and enthusiasm noticeably increased. For example, it was observed that students would sit up and hold their hands out waiting for the materials to be handed out. These types of hands-on activities, especially utilizing 3D models have had success in the past [11]. Incorporating hands-on activities with 3D models and other tactile materials generally increased engagement.

Students and mentors highlighted several activities as their favorites. One standout was the LEGO tactile art activity, where students created a piece of art after a discussion on tactile art. This was attributed to students being highly engaged when putting together their creations and talking to peers about their designs. When it came to sharing experiences with one another, students were very eager to explain their product and listened to others' presentations. Additionally, creating and printing models was a favorite with both students and mentors. Students were excited to create 3D models that reflected their hobbies and interests by looking for models on Thingiverse. This excitement increased when students received their 3D models back in physical form, showing each other and talking about changes they wanted to make to their design. The excitement around 3D modeling from these activities could also lead to increased interest in other STEM subjects [20], [21].

One outlier to this engagement with hands-on activities was the marshmallow challenge, in which students created towers using limited materials. While this activity was a hands-on activity and engaging for some, students mentioned they preferred the LEGO activity. One potential reason for this outlier was the lack of experience working in a team, and the emphasis of this activity to work with your teammates.

In comparison to the hands-on activities, during lectures, engagement tended to decline as many students seemed distracted and were less likely to participate in the discussions. One exception to this included the career panel featuring a blind entrepreneur. Students showed interest by asking questions and expressing enthusiasm about hearing from someone with similar experiences.

Despite the various reactions to the different activities, by the end of the workshop most students were able to identify at least one activity that was interesting and engaging for them. A few participants even mentioned an increased interest in an engineering or technical career field and that the engineering week was the most exciting career week they focused on during the camp.

5.2 Changes for Future Educational Curricula

Several insights from the workshop highlight opportunities to improve future curriculum design for individuals who are blind or low-vision. One challenge was that many activities depended on the student's level of self motivation when things became difficult. Some students stayed engaged throughout the workshop, but others were unsure why the tasks mattered or lost interest when the modeling became frustrating. Students who struggle to understand the activity typically have decreased motivation and interest [13]. Because there was no shared goal or central outcome to work toward, students' progress varied widely, and facilitators had limited tools to help re-engage those who stepped back. In future workshops, adding small milestones, optional guided challenges, or a final showcase could help students see their progress and feel a sense of purpose. These additions would provide gentle structure without removing the freedom of choice, and may help students with differing levels of interest or confidence stay connected to the experience.

Another area for improvement includes strengthening mentoring and instructional support. The mentors, who had varying degrees of available sight and limited engineering or 3D printing experience, were strong role models but often unsure how to help when students faced technical obstacles. Providing mentors with a short training session before the workshop, clarifying their roles, or pairing mentors and students based on shared needs or experiences could make these interactions more supportive. These types of training sessions can increase the confidence among mentors which has been shown to be vital in supporting students [9]. Another key lesson was the need for more differentiated learning. While the curriculum followed a single path, students came in with very different skill sets, comfort with spatial reasoning, and familiarity with modeling tools. Offering alternative software (such as text-based modeling for students who prefer it), tactile-first activities, or tiered project options would allow each student to learn at an appropriate pace. These adjustments would help the workshop feel more responsive and personalized, and they would make it easier for students of all levels to participate meaningfully in the design process.

5.3 Accessibility

From the workshop, several important themes emerged regarding accessibility. Reflecting on these elements is essential because understanding where students struggled to navigate and when certain spaces or materials were available, significantly shaped their overall experience. This workshop emphasized that preparing lectures, activities, and transitions requires thoughtful planning that takes variability into account.

Throughout the week, it was found that different aspects of the environment introduced challenges that could be avoided. For example, some of the most frequently used or desired spaces were located too far away from the main activity areas, and the overall layout of the building was more complex than anticipated. Both of these factors made navigation difficult not only for the students but also for the staff supporting them. This became even more evident on the final day when a sudden storm added complications and a layer of stress for transportation. Additionally, several participants noted that earlier cane-training sessions would have been beneficial in helping students feel more comfortable and oriented at the start of the week. Working on making the spaces more intuitive and providing convenient access to desired spaces will substantially improve the experience for students [37].

Accessibility to materials that supported activities and reinforced lecture topics had a significant impact on student's engagement. Throughout the week, engagement tended to dip during long stretches of lectures that weren't supported by hands-on activities. Students were noticeably more engaged when they could actively apply what they were learning. Having access to computers and printers through the whole workshop, and being able to incorporate more demonstrations with them would greatly improve engagement [11]. It was also suggested that if the printers had been introduced, physically, earlier in the week, that it would improve the students' understanding of the material and excitement about their projects through earlier stages of the process.

5.4 Lessons Learned

While there were several valuable lessons learned throughout the process of designing and implementing this workshop, this section will focus on three major lessons: Importance of Preparation, Need for Flexibility, and Use of Differentiated Learning.

5.4.1 Importance of Preparation

The team of staff and researchers spent months preparing for this workshop, planning out each session, and identifying learning objectives and activities. Time was spent discussing how each team member was going to contribute to the workshop sessions and what materials would need to be prepared prior to the workshop. Closer to the workshop, a session called Blind 101 was hosted for the team members who were sighted to learn more about interacting with individuals who are blind or low-vision. This was led by guidance from BISM and found to be extremely valuable to the team members who were sighted. Team members expressed the importance of being prepared for how to respectfully interact with the students who were blind or low-vision and how the Blind 101 session helped enable them to do so. Throughout the workshop, the mentors of the students, who were not part of the planning for the workshop, expressed an interest in being better prepared to support the students with 3D modeling and 3D printing. Similar to the Blind 101 session held for the team members who were sighted, it is suggested that in the future, the mentors have a similar session prior to the workshop that is 3D Modeling 101. This type of session will support the mentors and increase their confidence to better engage with students during the workshop [9].

5.4.2 Need for Flexibility

While the team of staff and researchers planned for a lot of different activities and scenarios, it is challenging to fully anticipate every possibility. There were many challenges and unknowns throughout the workshop that the team had to address and often needed to pivot quickly. For example, the exact skill sets and abilities of the students were unknown prior to the workshop. This meant that different levels of activities needed to be available for individuals with different skill sets [38]. Similarly, students had different levels of interest in the different activities. The team needed to be flexible and work with the different levels of interest and different skill sets to create an engaging environment and workshop for each student. In addition to being flexible to meet the needs of the students, there were various unexpected challenges with computer logins, building access, food, and more that all required the team to think quickly and transition as needed. Flexibility is always needed when planning any type of workshop, however, it is important to especially address the need for flexibility in this type of workshop as there is a paucity of documentation on how to implement 3D modeling workshops specifically for students who are blind or low-vision.

5.4.3 Use of Differentiated Learning

This lesson builds upon the Importance of Preparation and the Need for Flexibility and highlights the Use of Differentiated Learning. Differentiated learning refers to the design of more personalized activities for students with different skill levels [38]. For this workshop, activities were initially designed with the idea that all students would have similar levels of interest and skill sets. Instead, there was a wide range of interest in the different activities from no interest and even disgust to being absolutely engrossed with the activity. It is especially important for this type of workshop to prepare a variety of activities that would engage different students and meet them where they are. This could look like having different levels of a single activity that students could work through if they wanted [38]. For example, when 3D modeling was first introduced, students could start by making simple shapes, but as students progressed at their own speed, different and more complex shapes could be presented. In this workshop, there were also students with multiple disabilities which requires additional consideration to ensure all students are able to fully participate in the activities. One student who had a learning disability and limited confidence in using assistive technologies, found it difficult to conduct many of the tasks. It is important for students to have opportunities to learn about 3D modeling and 3D printing, and using differentiated learning is a valuable way to do so.

6 Conclusion

This paper describes a workshop that introduces engineering, 3D modeling, and 3D printing to a group of students who are blind or low-vision. This was a four-day workshop that used interactive and tactile activities and sessions to introduce students to the engineering design process and basic 3D modeling. Specifically, this paper details the successful elements of various activities such as the use of tactile materials such as LEGOs and Play-Doh to inspire design thinking. This paper also identifies areas of improvement like the importance of preparing all staff members who will be involved in the workshop and implementing differentiated learning to each activity to better match the student’s interest levels and skills. Introductory workshops to engineering and 3D modeling are important to continue developing as they expose students to potential career fields. Future work will focus on implementing the lessons learned from this study and utilizing these findings to guide the development of future workshops with students who are blind or low-vision.

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