ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #35268

Multi-semester Projects to Improve Braille Instruction for Visual Impairments

Dr. Daniel K. Jones P.E., State University of New York, Polytechnic Institute

Dr. Jones is Associate Professor of Mechanical Engineering Technology at SUNY Poly in Utica, NY. His teaching interests include machine design, mechanical measurements, vibrations, instrumentation, and assistive technology for people with physical disabilities. His recent research interests include measuring and analyzing EEG signals from the brain in response to visual stimuli.

Dr. Joanne M Joseph, SUNYPOLY

Joanne M. Joseph PhD is Psychologist and currently the Interim Dean of Health Sciences at SUNYPOLY. Dr. Joseph has colloborated with Dr. Daniel Jones and other faculty from the College of Engineering and Computer Science and the College of Arts and Science to create Minor Concentrations in Humanitarian Engineering, Humanitarian Engineering Technology and Humanitarian Studies. The minors represent a multidisciplinary effort directed to improving the quality of life for individuals with disabilities.

Multi-semester Projects to Improve Braille Instruction for Visual Impairments

Daniel K. Jones, Associate Professor, Mechanical Engineering Technology
Joanne Joseph, Professor, Community and Behavioral Health
State University of New York Polytechnic Institute

Abstract

Faculty and students have partnered with a local agency to engage students in the development of assistive technology for people who are blind or visually impaired. The agency identified the need for new equipment to assist with braille instruction since prior products had limitations making them difficult to use. Students from technical and non-technical disciplines worked together to develop new technology and prototypes. The agency then used the prototypes and provided feedback for improvements to be used as a starting point for the following semester. After several semester-by-semester iterations, a series of projects has proven to be an incredible learning opportunity which has led to development of real improvements in braille instruction.

Introduction

For many years, faculty at SUNY Polytechnic Institute (SUNY Poly) have worked with local community organizations to provide students project-based learning experiences developing assistive technology for people with disabilities. Most of these projects have been very effective at inspiring and motivating students to apply their technical skills to solve problems encountered in educational, occupational, and recreational tasks, as well as routine activities of daily living. However, the time constraints of a single semester made it difficult to provide technical solutions, get feedback from users, and incorporate changes needed to make a usable end product.

Background

The use of assistive technology in the classroom to enhance the learning experience for students with disabilities is a well-established field [1]. For children and students with visual impairments, tactile technology helps the learning process, especially when teaching the use of braille letters and numbers. Recent advances in 3D printing have provided opportunities to innovate methods for braille instruction, and several studies have evaluated the effectiveness of this technology for teaching [2], [3], [4]. 3D printers are also being used to create tactile maps which help people with impaired vision learn how to navigate new environments [5].

Academic and Community Partnership

SUNY Poly has partnered with the Central Association of the Blind and Visually Impaired (CABVI), an agency that provides a host of services to individuals who are blind and visually impaired, including educational and recreational services to infants and children up to age

eighteen. The staff at CABVI has a well-established history of working with individuals with disabilities, and so they have a long list of needs that can provide students with meaningful projects for many years to come. These projects involve a range of technical and non-technical issues that make them ideal for multi-disciplinary student teams.

Methodology

One of the projects identified by CABVI was the need for developmentally more appropriate braille blocks and toys for visually impaired and blind children. Teachers and family members help young preschool children who are just learning the braille code with wooden braille blocks, similar to conventional building blocks. The blocks have braille letters and numbers on the sides produced by rounded pegs glued at various positions to create the braille letter or number. A family member or teacher reads a number or letter printed on the back of each block without needing to know the braille code. A groove carved on the top of each block allowed the child distinguish the top from the bottom.

CABVI was no longer able to obtain these blocks, and so they were looking for an alternative that would allow children to continue learning braille. The design criteria for the new block includes one letter or number per block. The new design had to be easy to clean and large enough that it would not fit into the mouth of a child to prevent a choking hazard. They would primarily be used by children three to five years old, but also by older children and adults who become visually impaired.

Students in the Mechanical Engineering Technology (MET) program worked with students in the Community and Behavior Health (CBH) program to develop a prototype of the blocks and a braille scrabble game. CBH students provided the developmental specifications and evaluations for the blocks, and the MET students provided design details, manufacturing methods, and production of the prototypes. The objective was for students from dramatically different disciplines to work together and come up with new ideas that would otherwise not be possible.

Semester-by-semester Progress

The project commenced in the spring of 2017. CBH and MET students and faculty from SUNY Poly visited CABVI and listened to a series of staff presentations on potential projects. This led to several different capstone projects, one of which was the braille block project. The first capstone group produced braille tiles and a scrabble board with square braille blocks [6]. As shown in Figure 1, the initial designs were laid out using AutoCAD, and the final models were designed using SolidWorks.

Figure 1. Braille tile and scrabble board prototypes [6]

CBH and MET students met weekly to share design ideas. MET students created CAD models to show CBH students in order to discuss how the teachers and family members would use the different designs to teach braille to children. Students made prototypes using CubePro 3D printers, as shown in Figure 2, with dovetail slots on the sides to attach blocks side-by-side.

Figure 2. Braille tiles with dove-tail slots [6]

Students took these blocks to CABVI to use them and provide suggestions for improvement. CABVI teachers noted that the dove-tail slots were cumbersome and awkward, particularly for children who could not see the slots.

Throughout the course of this project, 3D printing technology has evolved, along with expertise of student workers in the 3D printing laboratories. In spring 2019, the braille blocks were improved by attaching magnets to the edges in order to hold blocks together side-by-side to create words. This also enabled blocks to stick to a whiteboard. Initially magnets were glued into holes on the blocks, but this was a potential hazard since children are likely to put the blocks into their mouths. Therefore the magnets were imbedded into the block. This was a challenge to stop the 3D print job, manually insert the magnets, and then restart the 3D printer without magnets being attracted to the nozzle of the printer. Manufacturing of the new version was finally accomplished using the ANet A6 and InstrRep A8 3D printers.

Figure 3. CABVI staff using “Brabble” Board

CABVI used the improved blocks, as shown in Figure 3, and provided feedback for improvements. For example, blind students felt small surface flaws, using them to “cheat” instead of learning the letter. Since the blocks were rectangular, they also needed away to hold the blocks in the correct orientation. To accommodate these recommendations, SUNY Poly students made smoother edges with improved 3D printers, and then deburred and sanded any remaining surface imperfections. A bump was printed on the top of each block, along with an indentation at the bottom, so the blind students could orient the blocks correctly.

A typical dimensioned CAD model is presented in Figure 4. Separate models were created for each letter and number. The most recent blocks have numbers and letters engraved on one side, and the corresponding braille symbols encoded on bumps on the other side as shown in Figure 5. A complete set of blocks consists of twenty-six letters and ten numbers, but it helps to have multiple vowels and numbers that are used more frequently. This means that at least fifty blocks are need for a functional set. Since it takes two to three hours to 3D print each block, a complete set requires 100-150 hours of print time. To scale up production, full-time staff on campus coordinated with student workers to 3D print several sets of braille blocks. CABVI teachers have used several sets of these braille blocks to teach children.

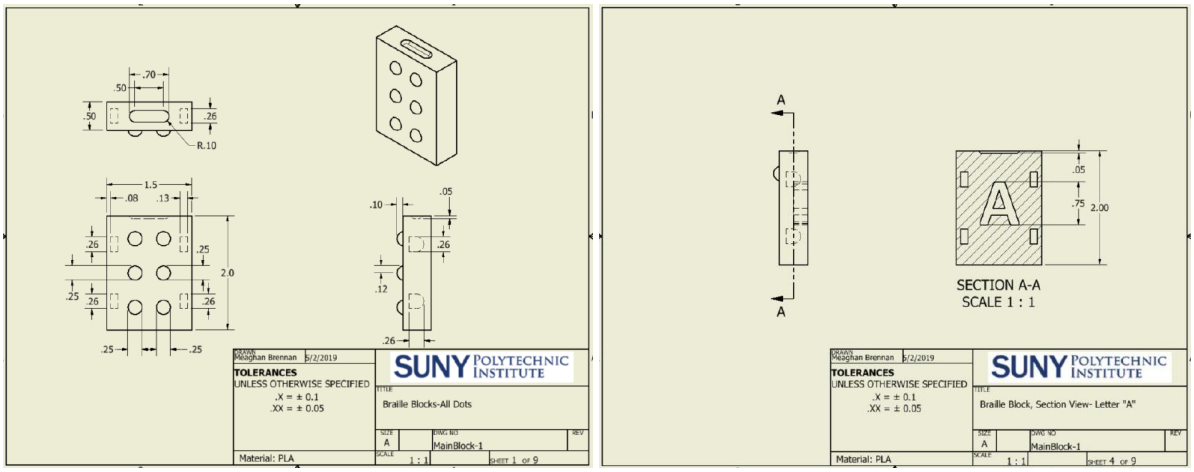

Figure 4. Sample CAD models [7].

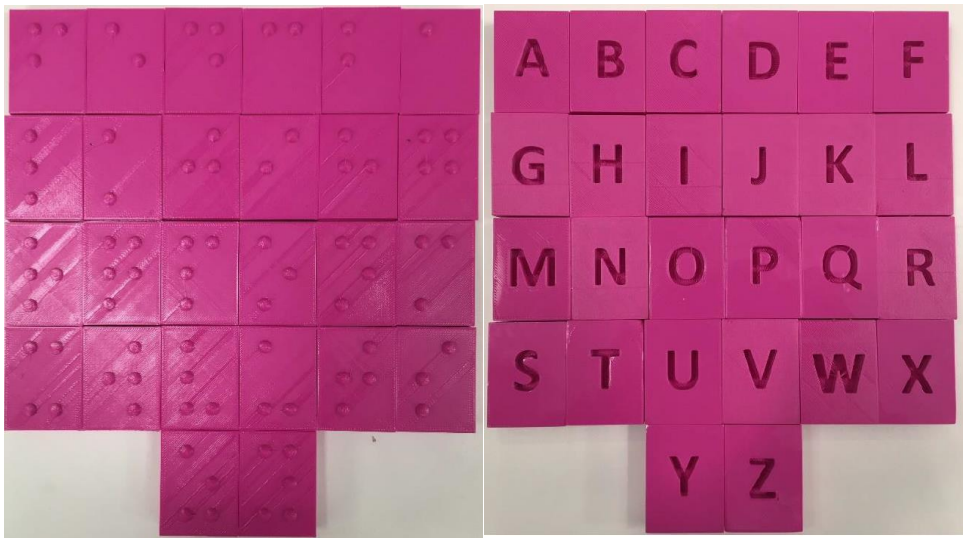

Figure 5. Set of most recent braille blocks [7].

The time and schedule constraints of a 15-week semester presented challenges when working with community agencies. Students were generally rushed at the end of the semester to complete prototypes, prepare presentations, and write final reports. After the semester, most of the students did not continue working on the projects, especially when they graduated. This made it difficult to incorporate feedback from CABVI. For these reasons, progress on the series of braille projects has been maintained by SUNY Poly faculty, staff, and student workers following up with CABVI teachers.

Outcomes

After two years of semester-by-semester iterations, a series of projects has proven to be an incredible learning opportunity which has led to development of real improvements in braille instruction. A positive side effect of the project was the MET and CBH students learned from each other and developed a much deeper appreciation and understanding for the diverse disciplines. Caryn Schweinsberg, a former CBH Student, stated: "A few years ago, I had the privilege of participating in an interdisciplinary project … with the engineering students involving the creation of braille blocks …. The experience and knowledge I gained through participating in this service based project was invaluable. It expanded my team building skills immensely, and taught me about the significant impact a multidisciplinary approach can have on a single goal. It also allowed me to gain a very different perspective on problem solving through the eyes of a different discipline. In addition to gaining experience and knowledge, I had the opportunity to be involved in developing a product that greatly impacted children with visual impairments. The benefit of this collaboration was significant and together we were able to create not only one successful product for the students at CABVI, but two."

The impact on the community partner was equally compelling. Kathy Beaver, Vice-President of Rehabilitation at CABVI, wrote: "For many years, corporations and not for profit businesses have partnered with colleges and universities to secure interns and recruit employees. Most recently, there has been renewed commitment by institutions of higher learning to ensure education is relevant to life after college with the development of student skill sets which, will hopefully, lead to workplace success. With this renewed commitment to quality education, new approaches to student engagement are emerging.

Over the past two years, SUNY Poly and CABVI have embraced a very innovative collaboration which maximizes student engagement and benefits the CABVI Rehabilitation Team. They have been working cooperatively to design equipment that will support rehabilitation staff as they provide therapy to patients. CABVI teachers identified a need they had for new equipment to support braille instruction. There were products on the market that provided some help in braille instruction, but they had limitations and were cumbersome to use. Specifics of what the teachers were looking to accomplish was shared with (the university) students.

SUNY Poly students embraced the challenge, assumed the project, designed and produced braille interlocking blocks. After a number of prototypes, and multiple test runs, we are very close to final product. Our collaboration with SUNY Poly has been both innovative and forward thinking. When Dr. Joseph reached out and inquired as to whether there was a project they could help with, I didn't know what to expect. Would we spend a lot to time and energy on an idea with no solution? If so, would the process of engagement be enough of a reward?"

Two years later, I can honestly say it was well worth the investment of time. Am I thrilled we have a product we can use? The answer is *most definitely*. However, more importantly, the strength in collaboration with universities and institutions of higher learning is a new level of innovation that will not only broaden the education of college students but connect them to communities, and, in turn, allow organizations such as CABVI to accomplish so much more."

Another important outcome of this project was the realization that it takes more than one semester to effectively work across the CBH and MET disciplines with the external partner CABVI. MET students must be open to non-technical recommendations that disrupt their ideas, along the multiple design iterations required for success. Recent MET capstone requirements have been expanded from a one- to a two-semester course sequence. This provides a more realistic timeframe for a thorough design, analysis, manufacturing, and debugging phases. It also accommodates the additional time needed to genuinely work with CBH students and incorporate their suggestions. However, the progress presented in this paper was accomplished in a series of single-semester projects. Each semester, a completely new group of students picked up where the prior students left off.

Future Plans

Informal feedback from CABVI teachers has been instrumental in the success of the new technology for braille instruction. Since the multi-disciplinary nature of these projects is relatively new at SUNY Poly, a formal assessment process has not yet been developed. Future plans are to develop quantitative surveys and rubrics to assess student learning related to multi-disciplinary teamwork. Additional assessment is also needed for braille teachers to formally document changes, assess the effectiveness of new technology, and make recommendations for improvements for the next round of student projects.

The teachers at CABVI have asked for many more sets of the blocks so children can take them home to study with their families. Recent quarantines due to the COVID-19 virus has suddenly increased the demand for the braille blocks for remote learning at home. It has not been safe for children to have face-to-face instruction, let along sharing blocks with others.

Current production using 3D printers is very time-consuming. Even though multiple blocks can be made simultaneously, 3D printing technology is not feasible for large scale production. To effectively learn braille, each child needs a complete set of numbers and letters with multiple vowels. Although there is a high demand at CABVI serving Central New York, the braille blocks could be used throughout the nation. They could also be translated into different languages. International demand for the braille blocks could potentially reach hundreds or thousands of blocks per day.

Large-scale production of braille blocks could be accomplished using modern injection-molding technology, which requires capital investment and partnering with organizations with relevant expertise. Designs for injection-molding would be different than those for 3D printing, and so ongoing partnership with CABVI, CBH, and MET will lead to ongoing projects. Students will continue to learn the value of inter-disciplinary teamwork while making valuable contributions to society.

Conclusion

The series of braille block projects has offered students and faculty a unique opportunity to work with community partners improving the quality of life for individuals facing health related problems and physical rehabilitation needs. Academically, the service-based projects advance student abilities to problem-solve and work productively as a member of a team. These are

critical skills needed for today's work-force. The multidisciplinary research teams allow for a more holistic approach to the understanding and implementation of technology to solve health related issues. For the community, the products and services resulting from these projects helps to improve their ability to address the needs of their constituents. In short, everyone wins from the multi-disciplinary approach and community partnerships.

Acknowledgement

The authors would like to thank Kathy Beaver, Betsy Harvey-Minutti, Kimberly Scerbo, and all of the other staff at CABVI for their contributions and valuable time spent working with our students. Without their ideas and feedback, this project would not have been possible. Their use of the new braille blocks for teaching children with visual impairments has been extremely motivational for faculty, students, and many others who just happened to find out about this work.

Bibliography

1. Dell, A.G., Newton, D.A., and Petroff, J.G., "Assistive technology in the classroom: enhancing the school experiences of students with disabilities," 3rd Edition, Pearson, 2017.
2. Agic, A., Mandic, L., and Gabrijelcic Tomc, H., "An innovative braille alphabet teaching tool for visual impaired individuals based on advanced tactile embossed 3D graphics," *Acta Graphica*, 29(1), 7-14, 2018.
3. Pantazis, A. and Priavolou, C., "3D printing as means of learning and communication: The 3Ducation project revisited, *Telematics and Informatics*, 34(8), 1465-1476, 2017.
4. Wonjin, J. et.al., "Introduction to 3D printing technology in the classroom for visually impaired students," *Journal of Visual Impairments & Blindness*, 110(2), 115-121, 2016.
5. Urbas, R., Pivar, M. and Elesini, U.S., "Development of tactile floor plan for the blind and visually impaired by 3D printing technique," *Journal of Graphic Engineering and Design*, 7(1), 19-26, 2016.
6. Mancini, D., and Nelson, D., "Braille Tiles and 'Brabble' Game for the CABVI," *Capstone report*, SUNY Polytechnic Institute, spring 2017.
7. Brennan, M., and Gee, S., "3D Printing Assistive Technologies for Individuals who are Visually Impaired," *Capstone report,* SUNY Polytechnic Institute, spring 2019.