Mechatronics Workshop for Elementary School Outreach

Devin R. Berg[1,*], Meghan Donahue[2], Matthew Wigdahl[3], and Charis Collins[3]

[1]Engineering & Technology Department, University of Wisconsin-Stout
[2]Stout Vocational Rehabilitation Institute, University of Wisconsin-Stout
[3]Oaklawn Elementary School, School District of the Menomonie Area
[*]Corresponding author: bergdev@uwstout.edu

Introduction

In an attempt to engage a classroom of fifth-grade students in an engineering design experience, we took advantage of the prior experiences of a larger collaboration which demonstrated that these students gravitate towards projects which involve electronics while also providing an opportunity to help people[1]. The field of assistive technology, which provides a means of achieving greater independence and standard of living through the integration of technology with the tasks of everyday life and work, served as a suitable application for the student's natural inclinations towards helping others. Supporting evidence was also found in the literature where it is argued that assistive technology is a field that provides a rich opportunity for students to engage with their peers, their community, and the world at large in a meaningful way[2,3]. Further, the use of project-based design experiences has been shown to improve student engagement, use of divergent thinking, and teamwork skills[4,5].

This paper reports on the outcomes of this workshop, constructed to introduce the students to the design process from an engineering context, mechatronics, and assistive technology. The workshop focused on design of a mechatronic device using an Arduino inventor kit. The workshop introduced fundamentals of connecting the Arduino to a laptop, wiring simple circuits, and coding in the C++ programming language. Students were also briefed on the background of the field of assistive technology and were presented with a design challenge which would require them to design and prototype an assistive technology device to improve the daily life for a particular client.

Workshop Details

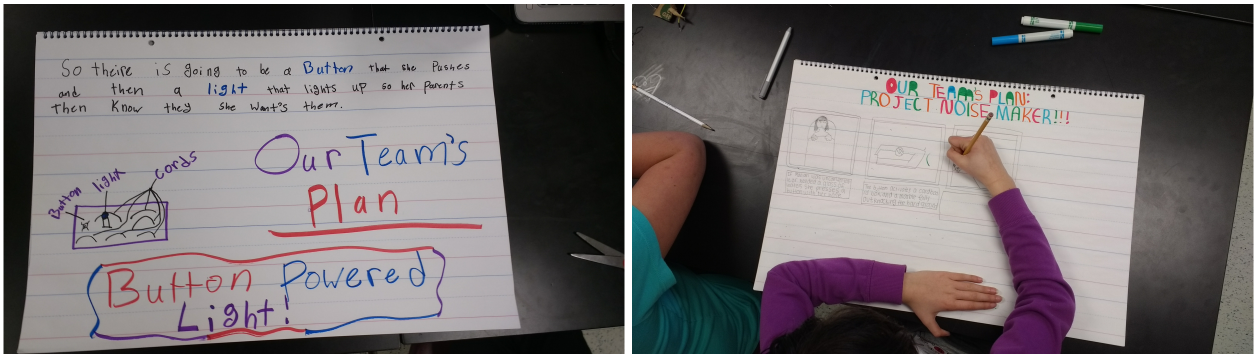
The workshop took place at Oaklawn Elementary School and was a one day event centered around mechatronic design for assistive technology. After a brief introduction to the day's activities, an opening presentation (see Figure 1a) was used to provide insight into the engineering design process and its application to assistive technology[6]. A rehabilitation engineering framework was used to ground the process by which the students would approach the design process with special emphasis given to considering the human element when defining the problem, critical to design for assistive technology[7,8,9]. At the conclusion of this introductory presentation, the students were presented with a design challenge. A hypothetical situation was posed in which a client with cerebral palsy is in need of a device to get her parent's attention during the night when she is alone in her room. Inspiration was provided by an available online video titled, "Toronto girl with cerebral palsy finds her voice" (`https://youtu.be/OTLOrsBTrVI`) in which the story of a young girl named Maria is presented. Students were told that they have access to LEDs, motors, an Arduino, and other associated electronic components as well as materials such as cardboard, construction paper, or paper clips in order to provide a solution to this problem.

After completion of the introductory presentation, an interactive presentation on the basics of mechatronics was delivered by a volunteer UW-Stout engineering student (Figure 1b). During this presentation, the students were shown how to wire an LED and a DC motor to an Arduino using a breadboard. Workshop volunteers circulated around the room to ensure that all of the students were progressing through each step. Example C++ code was provided such that the students could make the LEDs blink and operate the DC motor. Similarly, each aspect of the code was described and the students attempted to modify the code at each stage in order to learn the function of each line.

(a) (b)

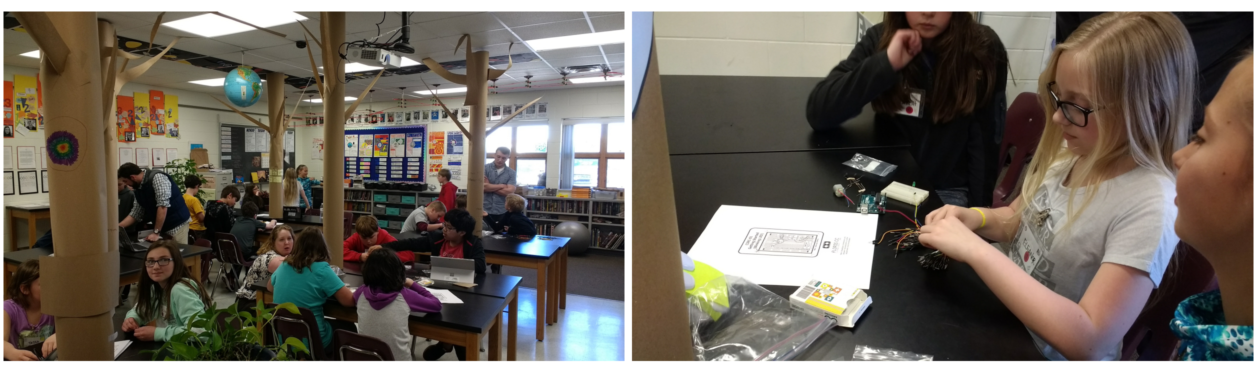
Figure 1: Presenting fundamentals of (a) rehabilitation engineering and assistive technology and (b) mechatronics.

This phase of the workshop was completed once each of the students seemed comfortable with the basics of wiring a simple circuit and modifying the corresponding code to operate it. The students were then formed into groups and tasked with brainstorming a solution to the posed design problem. The students were given freedom to approach the problem however they chose while the workshop volunteers provided support. The groups first used storyboards to record their ideas and draw plans for how they would prototype their designs (see Figure 2). Volunteers helped answer questions and provide feedback on the student's preliminary designs. The volunteers attempted to minimize the pursuit of designs that would be difficult to prototype using the provided materials. The students also used this time to construct prototypes of their designs using the provided equipment (see Figure 3). Once again, volunteers circulated the room to troubleshoot technical issues that the students encountered while wiring circuits, writing code, or assembling mechanical components.



(a) (b)

Figure 2: Storyboards demonstrating how the students approached planning of their design.



(a) (b)

Figure 3: Students working on (a) ideation and (b) electromechanical assembly.

Outcomes

After the conclusion of the workshop, the students were asked to reflect on their experience including items such as the skills they feel they learned and their interest in engineering design. Similarly, the workshop volunteers were asked to reflect on their experience leading the workshop, describe any observations they made, and to help identify things that worked well and things that could be improved.

The students were asked about their prior experience using the Arduino platform. For 80% of the students, this was their first time using an Arduino. However, only 18% reported that this was their first time writing code. Their prior experience with writing code consisted primarily of participating in the annual "Hour of Code" (`https://hourofcode.com/`) event as well as some graphical programming of LEGO Mindstorms robots. The most common theme that arose from student feedback included the difficulty that they experienced at first. However, it was also commonly expressed that with time and assistance, the task became easier. As one student remarked,

> "It was really really fun and it was hard at first, but after a while we found out if we all worked on different parts and collaborated it would be easier."

When asked about the experience of working on an assistive technology design project, several students noted that having to carefully consider the needs of the client made the problem more challenging but at the same time they enjoyed that they had a clear outcome or objective and that this outcome would directly help someone. Further, others noted that they felt more pressure to be successful with their design since there is someone else depending on you as compared to making something for yourself. Finally, students were asked about their experience using the engineering design process. They primarily reported that the step-by-step process made it easier to move forward any time they got stuck. They also felt that using cardboard to prototype their ideas early in the process (this was encouraged during the design phase) made it easier to see where the idea worked and where there were still issues to be resolved.

Feedback was also solicited from the workshop volunteers. The volunteers noted that the activity was appropriately selected for the age group and that the students seemed engaged throughout. They further observed that the students made good use of their time, came up with creative designs to solve the problem provided, used their prototyping resources effectively, and did a good job of proposing design improvements at the conclusion of the workshop. The primary concern was the limited time available for each phase of the workshop with a recommendation to increase the time by possibly extending the workshop activities over multiple days to allow for scaffolding.

Conclusions

From the perspective of the workshop organizers, the student's participation in the workshop activities was exemplary and the interactions between the students and the volunteers supported a collaborative learning environment. While the workshop was quite successful for the first time attempting such an endeavor, the need for more time was clear. Future iterations of this same workshop will be formatted to allow for more incremental student interventions. Through additional grant funding, classroom Arduino kits have been purchased and will be supplied to the partnering classroom early in the academic year to allow the students to gain familiarity prior to any classroom visits from university personnel. This will allow the workshop time to be used more for project design and less for teaching introductory mechatronics. Additionally, multiple classroom visits will be conducted to allow greater scaffolding of learning. The focus of early visits will be on the engineering design process using examples and role playing while later visits will involve prototyping and design analysis. This will allow for study of how the students approach engineering design in comparison with university students undertaking similar activities.

Acknowledgements

This work was funded by the Stout University Foundation under the College Collaboration Grant program. The authors would also like to thank the student volunteers who helped with organizing and operating the workshop.

References

[1] Devin R. Berg, Matthew Wigdahl, and Charis Collins. Assistive technology for freshman design and K-12 outreach. In *2017 ASEE Annual Conference & Exposition*, Columbus, Ohio, June 2017. ASEE Conferences. URL https://peer.asee.org/27916.

[2] Chuck Hitchcock and Skip Stahl. Assistive technology, universal design, universal design for learning: Improved learning opportunities. *Journal of Special Education Technology*, 18(4):45–52, 2003. doi: 10.1177/016264340301800404. URL http://doi.org/10.1177/016264340301800404.

[3] Janis P Terpenny, Richard M Goff, Mitzi R Vernon, and William R Green. Utilizing assistive technology design projects and interdisciplinary teams to foster inquiry and learning in engineering design. *International Journal of Engineering Education*, 22(3):609, 2006. URL http://lib.dr.iastate.edu/edesign_pubs/11/.

[4] Mary Carpenter, Logan Edward Micher, Chris Yakymyshyn, Jorge Vargas, and Christina Drake. Proposal-based learning for freshman introduction to engineering. In *2016 ASEE Annual Conference & Exposition*, New Orleans, Louisiana, June 2016. ASEE Conferences. doi: 10.18260/p.26009. URL https://peer.asee.org/26009.

[5] Mary Carpenter, Chris Yakymyshyn, Logan Edward Micher, and Ashly Locke. Improved student engagement through project-based learning in freshman engineering design. In *2016 ASEE Annual Conference & Exposition*, New Orleans, Louisiana, June 2016. ASEE Conferences. doi: 10.18260/p.25602. URL https://peer.asee.org/25602.

[6] Meghan Donahue and Devin Berg. Engineering for People With Disabilities. 4 2017. doi: 10.6084/m9.figshare.4902071.v1. URL http://doi.org/10.6084/m9.figshare.4902071.v1.

[7] David Poulson and Simon Richardson. USERfit–a framework for user centred design in assistive technology. *Technology and Disability*, 9(3):163–171, 1998.

[8] David H Rose, Ted S Hasselbring, Skip Stahl, and Joy Zabala. Assistive technology and universal design for learning: Two sides of the same coin. *Handbook of special education technology research and practice*, pages 507–518, 2005.

[9] Grace Chao. What is Design Thinking?, 2015. URL http://www.stanforddaily.com/what-is-design-thinking/.