Toy Adaptation in Undergraduate Education and Outreach: An Initial Examination into Participant Experience and Perceptions (Work in Progress)

Ms. Molly Y. Mollica, University of Washington

Molly Mollica earned her BS in Biomedical Engineering and her MS in Mechanical Engineering from Ohio State University. She is currently a PhD student in Bioengineering at the University of Washington.

Dr. Heather A. Feldner, University of Washington

Heather Feldner received her BS in Human Biology and Master's degree in Physical Therapy from Marquette University. She has been a practicing pediatric physical therapist for 16 years, and began teaching in the University of Illinois at Chicago's DPT program in 2010. She became a board certified pediatric clinical specialist in 2012, completed her Assistive Technology Certificate from UIC in 2015, and earned her PhD in Disability Studies from UIC in 2016. She joined the University of Washington's Department of Mechanical Engineering as a postdoctoral researcher in September of 2016. Heather has a special interest in user-centered design and participatory research, and has been a lab member of the GoBabyGo program, which creates custom safety and accessibility modifications to commercially available battery powered toy ride-on cars for children with disabilities, since 2012. Heather's research focuses on investigating the impact of traditional and alternative mobility technologies on the experiences of people with disabilities and their families, and the direct and indirect influences of physical and social environments, technology design, industry, and disability orientation on those experiences.

Dr. Anat Caspi, University of Washington

Dr. Anat Caspi is Director of the Taskar Center for Accessible Technology housed by the Department of Computer Science and Engineering at the University of Washington. Caspi received her PhD from the Joint Program in BioEngineering at University of California, Berkeley & UCSF. Her research interests are in the areas of ubiquitous computing and data science. Caspi is interested in ways by which universal design, collaborative commons and cooperation can challenge and transform computing disciplines and technology design.

Dr. Katherine M. Steele, University of Washington

Dr. Steele is an assistant professor in mechanical engineering at the University of Washington. She received her BS in engineering from the Colorado School of Mines and MS and PhD in mechanical engineering from Stanford University. She leads the Ability & Innovation Lab, dedicated to designing new tools and techniques to improve human ability through engineering, and also a leader of AccessEngineering to enable individuals with disabilities to pursue careers in engineering. Dr. Steele previously worked in multiple hospitals as an engineer, including The Children's Hospital of Colorado, Lucille Packard Children's Hospital, and the Rehabilitation Institute of Chicago.

Dr. Dianne Grayce Hendricks, University of Washington

Dr. Dianne G. Hendricks is a Lecturer in the Department of Bioengineering at the University of Washington, where she leads the Bioengineering Outreach Initiative, Bioengineering Honors Program, and the Bioengineering Summer Camp in Global Health. She holds a PhD in Genetics from Duke University, and BS in Molecular Biology and BA in Psychology from the University of Texas at Austin. Dr. Hendricks' teaching activities at the University of Washington include introductory and honors courses in bioengineering, tissue and protein engineering lab courses, bioengineering ethics, leadership, and bioengineering capstone writing and design courses. She is committed to enhancing diversity and inclusivity in engineering, and creating opportunities for undergraduate students to engage in K-12 educational outreach. Dr. Hendricks has over a decade of experience leading educational outreach and summer camp programs at both Duke University and the University of Washington.

Work In Progress: Toy Adaptation in Undergraduate Education and Outreach - An Initial Examination into Participant Experience and Perceptions

Service learning is a powerful educational method for delivering engineering curricula [1, 2] while benefiting student retention, personal development, and community connections [3, 4]. Furthermore, positive societal impact is especially important to underrepresented students in career selection [5, 6] and classes or projects with clear engineering-service components commonly attract a higher percentage of students from underrepresented groups [7, 8]. In this work-in-progress, we examine our initial efforts in implementing toy adaptation to enhance engineering education and to serve our broader community.

What is an adapted toy?

An adapted toy has modified activation, function, or other components to increase accessibility and enhance the user's experience. Here, we use "adapted toy" exclusively for a battery-operated toy that has been modified with the addition of a jack. This jack allows for connection to a wide variety of alternative activation switches so that users can activate the toy using their unique abilities. For example, as shown in Figure 1, the dog toy is traditionally activated by squeezing its torso. However, as an adapted toy, a variety of switches can be plugged into that jack so that the toy can be activated in alternative ways. Toys are essential for development because play introduces novel concepts and experiences such as understanding cause and effect, developing communication and motor skills, and providing opportunities for independent play and decision-making [9, 10]. Despite the developmental importance of toys, people with disabilities are frequently unable to access off-the-shelf toys, making the developmental benefits unattainable.

Figure 1: Adapted toy and sample activation switches: The dog is an example of an adapted toy with an additional female jack universal switch. This adapted toy can be activated by a variety of alternative activation movements including pushing a large button, tilting one's head, pulling a string, biting, or pushing one's jaw downward. Images from Enabling Devices [11] and Ablenet [12].

Toy adaptation in engineering

Adapted toys are generally not available in stores, but can be purchased through specialized websites for 3-5 times the cost of the non-adapted toy. To provide access to affordable toys, non-profits such as RePlay For Kids (replayforkids.org; Medina, Ohio), Santa's Little Hackers (santaslittlehackers.com; Westminster, CO), and East Tennessee Technology Access Center (ettac.org; Knoxville Tennessee) adapt and donate toys to local families and a national network of lending libraries. A program initiated at the University of Delaware (http://sites.udel.edu/gobabygo/) adapts ride-on cars for children with disabilities and is focused on the developmental impact of mobility and the technical elements of the modification [13-15].

To our knowledge, toy adaptation was first used as an educational and research tool by The Ohio State University Toy Adaptation Program (https://u.osu.edu/osutap/) [16-18]. This program seeks to inspire engineering students through community service while teaching concepts such as circuitry and reverse engineering. At the University of Washington (UW), we aim to learn from and complement these programs by addressing several aspects of accessible design and play technologies through education, outreach, and research that includes students, clinicians, and community members.

Toy adaptation is an enjoyable and appealing approach to teach engineering skills

Toy adaptation introduces many fundamental engineering skills and concepts including reverse engineering, problem solving, basic circuitry, soldering, and teamwork. The process typically takes two hours and supplies cost $1 per toy. As shown in Figure 2, this includes opening the electronic toy and finding the circuit that controls its activation (Figure 2A and B). A piece of wire is then used to determine how the circuit is completed to activate the toy, thereby initiating sounds, lights, and/or movement (Figure 2C, enlarged in D). A female jack is soldered to a wire and the other end of that wire is soldered to the identified points on the circuit (Figure 2E and F). Finally, the toy is closed (Figure 2G) and repackaged. Toy adaptation is a low-risk introduction to design, circuitry, soldering, and use of basic hand tools. In addition, the clear societal impact of toy adaptation may make it an attractive engineering application to underrepresented students, whose educational and career choices are especially motivated by opportunities to make a difference in their communities and help others [5-8].

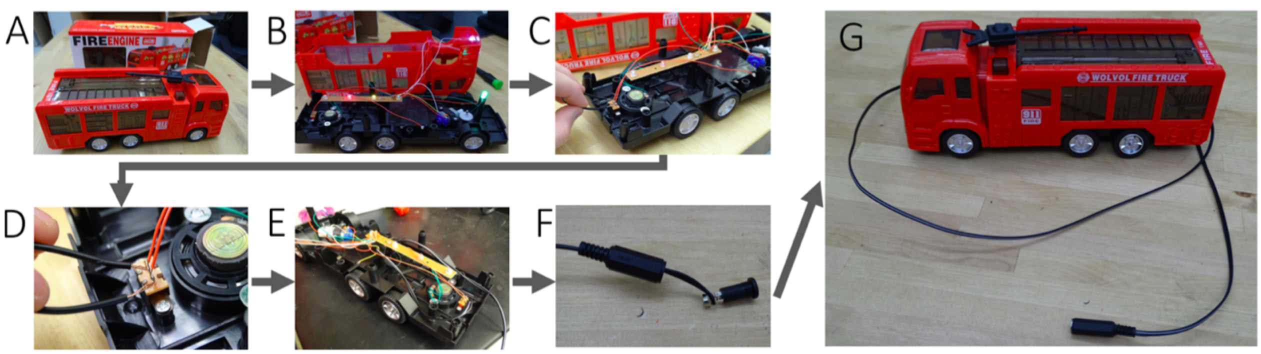

Figure 2: Toy Adaptation Process: Toy is opened (A-B), its circuit is analyzed (C-D), and a jack is soldered into the circuit (E-G.)

Initial efforts to engage students with toy adaptation at University of Washington

To gain an initial understanding of participant experiences with toy adaptation, we held three education and outreach-oriented events: (1) educational outreach events in which middle and high school students visited UW Bioengineering to explore bioengineering applications including toy adaptation, (2) a clinical outreach event in which undergraduate senior bioengineering students trained local clinicians in toy adaptation, and (3) a “Holiday Toy Hack” in which 60 university and community participants adapted toys to fulfill holiday gift requests.

Assessment of participant experiences and perceptions

Survey data on participants’ experience of the event, perceptions of disability, and perceived impact of toy adaptation as an engineering application were collected at the clinician training and Holiday Toy Hack. Using methodology approved by the UW Institutional Review Board for Human Subjects Research, anonymous survey data were received from 63 participants. A Likert scale questionnaire was used to rank participant responses on a 5-point scale, from *strongly disagree* (1) to *strongly agree* (5). Sample questions and responses are shown in Figure 3.

In agreement with a previous report [16], participants overwhelmingly enjoyed the toy adaptation experience (mean=4.79, standard deviation (SD)=0.41), with a majority of participants responding “strongly agree” and all other participants responding “agree” to the statement “I enjoyed this experience.” Responses about whether toy adaptation is challenging varied. While the mean was 3.20 (SD=1.02), students seemed to think the experience was less challenging (mean=2.92, SD=1.12) than non-students (mean=3.44, SD=0.93). However, this difference was not statistically significant when analyzed via Mann-Whitney *U* test. Participants agreed with the statements “This experience helped me see how engineering can have a direct impact on people” (mean=4.59, SD=0.60) and “This experience helped me feel more connected to the field of engineering” (mean=4.38, SD=0.75). In addition to questions about engineering, a number of questions assessed perceptions of disability. Interestingly, participants who had more frequent interactions with people with disabilities were, on average, less likely to feel sorry for them. In response to the statement “I feel sorry for people with disabilities,” the mean score for participants that interacted more than once per week with individuals with disabilities was 2.65 (SD=1.07) versus 3.37 (SD=0.88) for participants with interaction less than once per week. When tested with a Mann-Whitney *U* test, this difference was statistically significant (p = 0.26.)

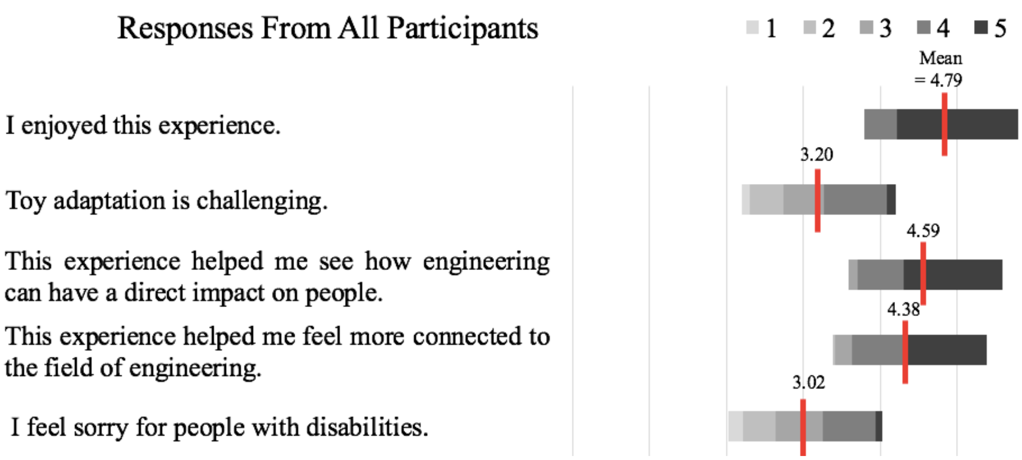

Figure 3: Responses from all participants. Participants responded on a 1-5 scale where 1=Strongly Disagree (shown in light gray), 2=Disagree, 3= Neutral, 4=Agree, and 5= Strongly Agree (shown in black). The vertical line indicates the mean of all responses.

It is also promising that while the Holiday Toy Hack was advertised indiscriminately across the UW College of Engineering, which is 27% female [19], 64% of student participants were female. Although a small sample (n=25), increased voluntary involvement from students in underrepresented groups to service-related engineering projects aligns with other studies [7, 8].

In the free response section of the survey, students at the Holiday Toy Hack highlighted the importance of connections across the broader UW community. One student commented, “Everyone is in a program that does different things, but we can all be related to the toy hack. I liked getting to meet students from other programs.” Another student commented that “seeing the kids use the toys” was one of the most positive aspects of the event.

Future Directions

Our preliminary data indicate that participants in our toy adaptation events enjoyed the experience, observed the direct impact of engineering through toy adaptation, and felt more connected to the engineering field as a result. We seek to continue toy adaptation efforts within a multidisciplinary team that will expand on this work-in-progress and encompass teaching, research, and outreach.

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References

[1] Oakes, W., Duffy, J., Jacobius, T., Linos, P., Lord, S., Schultz, W. W., & Smith, A. (2002). Service-learning in engineering. In *Frontiers in Education, 2002. FIE 2002. 32nd Annual* (Vol. 2, pp. F3A-F3A). IEEE.

[2] Duffy, J., Tsang, E., & Lord, S. Service-learning in engineering: What why and how? *ASEE Annual Conference 2000*.

[3] Eyler, J., & Giles Jr, D. E. (1999). Where's the Learning in Service-Learning? Jossey-Bass Higher and Adult Education Series.

[4] Sax, L. J., Astin, A. W., & Avalos, J. (1999). Long-term effects of volunteerism during the undergraduate years. *The review of higher education*, *22*(2), 187-202.

[5] National Academy of Engineering (2008). Changing the Conversation: Messages for Improving Public Understanding of Engineering.

[6] Google (2014). Women Who Choose Computer Science – What Really Matters.

[7] Davis, R. E., Krishnan, S., Nilsson, T. L., & Rimland, P. F. (2014). IDEAS: Interdisciplinary Design Engineering and Service. *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, 165-179.

[8] Rader, C., Hakkarinen, D., Moskal, B. M., & Hellman, K. (2011, March). Exploring the appeal of socially relevant computing: are students interested in socially relevant problems?. *Proceedings of the 42nd ACM Technical Symposium on Computer Science Education* (pp. 423-428). ACM.

[9] Missiuna, C., & Pollock, N. (1991). Play deprivation in children with physical disabilities: The role of the occupational therapist in preventing secondary disability. *American Journal of Occupational Therapy*, *45*(10), 882-888.

[10] Ginsburg, K. R. (2007). The importance of play in promoting healthy child development and maintaining strong parent-child bonds. *Pediatrics*, *119*(1), 182-191.

[11] *Enabling Devices*. Available from: https://enablingdevices.com.

[12] *AbleNet -- Solutions for Individuals with Disabilities*. Available from: https://www.ablenetinc.com.

[13] Huang, H. H., & Galloway, J. C. (2012). Modified ride-on toy cars for early power mobility: a technical report. *Pediatric Physical Therapy*, *24*(2), 149.

[14] Huang, H. H., Ragonesi, C. B., Stoner, T., Peffley, T., & Galloway, J. C. (2014). Modified toy cars for mobility and socialization: case report of a child with cerebral palsy. *Pediatric Physical Therapy*, *26*(1), 76-84.

[15] Logan, S. W., Feldner, H. A., Galloway, J. C., & Huang, H. H. (2016). Modified ride-on car use by children with complex medical needs. *Pediatric Physical Therapy*, *28*(1), 100-107.

[16] Mollica, M.Y., Kajfez, R.L., Riter, E.R., West, M., Vuyk, P., Community Service as a Means of Engineering Inspiration: An Initial Investigation into the Impact of the Toy Adaptation Program. *ASEE Annual Conference 2016*.

[17] Stavridis, O.M., Kajfez, R.L., Riter, E.R., Mollica, M.Y., Modeling real-world objects: connecting SolidWorks to toy adaptation. *Frontiers in Education Conference 2016*.

[18] Kajfez, R., Vuyk, P., Mollica, M., Riter, E., West, M., Toy Adaptation Program Workshop: Enriching First-Year Engineers by Teaching the Electronic Toy Adaptation Process. *First Year Engineering Experience ASEE Conference 2016.*

[19] University of Washington, College of Engineering: Mission, Facts, and Stats. http://www.engr.washington.edu/about/mission