Accessibility, Making and Tactile Robotics: Facilitating Collaborative Learning and Computational Thinking for Learners With Visual Impairments

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Abstract: This poster focuses on accessibility concerns that learners with visual impairments (LVIs) face in making environments, particularly with contemporary toolkits. This exploratory study was conducted over a three-day summer making workshop with visually impaired high school students to explore some major challenges and potentials of tangible making and robotics platforms, utilizing KIBO as a model. We explored how a tangible coding platform (KIBO) and accessible design modifications affected individual and collaborative group interaction and cognition.

Introduction

With the development of inexpensive maker tools such as the Raspberry Pi and Arduino microcontroller, making and robotics have become more accessible for novices and children than ever before (Halverson & Sheridan, 2014). However, learners with disabilities, in general, have had limited access to the maker movement, along with other opportunities to learn coding and design (Brady, Salas, Nuriddin, Rodgers, & Subramaniam, 2014). Drawing upon our framework for accessible makerspaces (Figure 1), this paper details a robotics-based maker workshop tailored for high school and young adult learners with visual impairments (LVIs). We investigated the following research questions: How do LVIs engage with platforms that are tangibly accessible? How does the accessibility of the tools affect learners' self-efficacy and collaborative interactions? What design elements do LVIs express would be beneficial for equitable co-creation and collaborative learning?

Methods

All data were collected from five of the nine participants (aged 15 through 19) who fully consented. Participants attended a three-day making workshop (each session between 1-1.5 hours) for high school and young adult learners with visual impairments in the Northeastern United States. KIBO (Kinder Lab, 2017), a wooden block-based tangible robotic kit (Figure 2) designed to learn core programming concepts through play, was utilized for workshop activities both without (Day 1) and with (Day 2 and 3) accessibility modifications. The study utilized comparative case study research design (Stake, 2008), with microanalytic video analysis, open-response pre- and post- questionnaires, in-depth focus group interviews, and think-aloud protocols where learners would vocalize their actions. We analyzed each source to understand how accessibility affected both individual and collaborative group interaction and cognition with the artifacts. Due to limited space, this poster focuses on two participants: Aaron (19-year-old, African American male), who had functional low vision from group A, and Mary (16-year-old, Caucasian female), who was nearly blind, from group B.

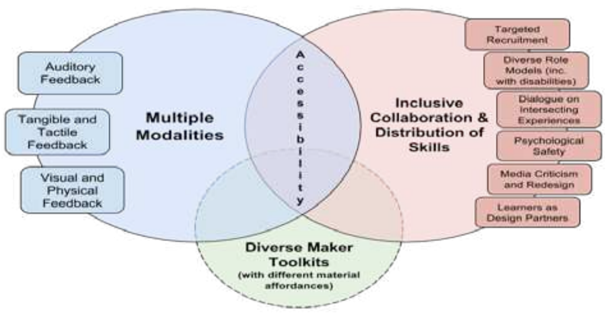

Figure 1 (left). Framework for Accessible Makerspaces. Figure 2 (right). Kibo Robot (Kinder Lab, 2017).

Case studies

On the first day, a full set of KIBO robotics kits were distributed to each group without any accessibility modifications. Aaron often deferred to his completely blind group member, who had some experience coding and constructing model cars. He primarily participated peripherally or by assisting others, such as when he helped the completely blind group member look for a battery and tried to assemble the robot collaboratively at the instruction of others. In group B, Mary who was nearly blind kept asking a fellow groupmate with a moderate visual impairment to identify each block. When scanning each block, Mary tended to observe closely or listen to her fellow group member with better visual acuity. Though this better sighted group mater tended to dominate most activities, Mary moved from peripherally observing to block finding.

On the second day, two accessibility considerations were added to the kits: (1) braille labels for each of the function and parameter blocks for additional tactile cues; and (2) an organizing system using three different plastic containers (i.e., input/sensor; output/actuator; and condition/loop groups). The organizing system provided students a logical and tangible structure for finding blocks and parameters. During day 2, with the absence of more vocal group members, Aaron changed from a peripheral observer to a block scanner. However, he did not benefit from the braille addition since he did not know braille. During scanning, he tried to employ alternative sensory feedback, such as the auditory cues, from KIBO after each scan. However, he was still sensitive to including the completely blind group mate, who would play with the blocks while they discussed them and hit the “play” button on KIBO to start the actions they scanned. Despite his efforts, scanning blocks was not a simple enterprise due to KIBO’s inherent scanner inconsistencies. Though Aaron had some visual acuity, the finicky nature of scanning made it even more difficult to have a mastery experience with the toolkit. Mary missed this session so her experience with the accessibility modification was captured on the following day.

On day 3, we integrated a race competition between groups A and B to encourage the use of different computational concepts and practices. Aaron was the only active participant in group A on the last day while the others remained uninvolved. He handed the KIBO scanner to one of the other group members who could see better than him to scan what he programmed. Their KIBO did not work as intended and Aaron began to debug his code by vocalizing it out loud. Because Aaron and his teammate spent too much time solving the first mission, they had to end their program in the middle of race; however, in contrast to the first day, Aaron was actively engaged in the hands-on activity and attempted to keep solving the problems collectively by allowing other group members to contribute. In group B, Mary was more actively engaged in the workshop compared to the first day by reading the braille labels on each block. When the group struggled with their coding for the first mission, she took the lead to debug the program. She tried to scan the blocks even though the scanner did not have an accessibility modification: “May I scan?” she asks as she tries to take the KIBO from the more sighted group member. When the group was addressing the final mission, Mary debated with the member with more visual acuity, who had taken on a dominant role: “You have to put the ‘forward’ before the ‘repeat’…. You're having it repeat the song.” While Mary’s new code was not technically correct, it is more important to note her changing role within the group over time from a peripheral observer to block-finder and active problem solver.

Discussion and conclusion

Throughout the activities, we found some expected finings as well as some surprising ones. For example, we found that visual acuity affected participation. Learners who were completely blind or had lower vision were sometimes limited in their full participation and engagement. Conversely, engaging in hands-on practices alone were not necessarily evidence of understanding; sometimes a learner took on that role due to their visual acuity while a lower vision learner provided content expertise. However, we also found that visual impairments did not speak to the full range of complexity observed. For example, some lower vision learners were vocal in being included in the collaborative work, whereas, some learners with better visual acuity self-selected to engage in peripheral learning for a variety of other complex reasons, such as Aaron, who had never had the opportunity to engage in comparable activities. Moreover, the addition of braille was helpful for some, but limiting for others for similar issues related to prior opportunities. As learners with a range of visual impairments and access to resources, they helped reveal that design for accessibility has to be more reflexive. We recommend that the field be cognizant of including varied material affordances that would be accessible to a wide range of learners with disabilities, but also consider participatory design practices for a diverse range of learners.

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