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Teaching Assistive Robotics through Co-Curricular Playful Engineering Workshops (RTP, Diversity)

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Abstract

Accessible design is a critical part of engineering education and training, but is often neglected in early engineering experiences and relegated to graduate-level or elective classes at the university level due to curriculum pressure. Assistive technology design and principles, similarly, are rarely taught in elementary, secondary, or even undergraduate courses. However, the principles of assistive robotics are not complex—they are comprehensible to even the youngest students, and may be more interesting to female students than "classical" introductory robotics projects.

Our work is not the first to identify this connection and use assistive design to engage students, especially female students, in primary-school engineering curriculum. However, the majority of these curricula focus on a charity model of assistive technology, with a non-disabled engineer creating something for a disabled person (or sometimes animal) who is presumed to contribute little or nothing to the design or manufacturing process (and is typically not present and represented only via a user profile or needs analysis).

To this end, we propose a novel structure for introducing design principles for do-it-yourself assistive technology at the K-12 level through a co-curricular assistive robotics workshop. In our workshop, students (whether or not they identify as disabled) are simultaneously learning technical skills for building robots and about user-centered, DIY assistive design and accessibility. We conducted a study overlaid on a full-day instance of this workshop that we co-hosted with a local Girl Scout organization. We present results from pre- and post-workshop surveys of the children and chaperones who attended, as well as from observations of the workshop activities. Our playful design workshop features open-ended, child-led projects designing assistive robotics for themselves, centering the idea of both assistive technology and assistive technology design as tools for empowering users of assistive technology.

1 Introduction

It is estimated that $15 - 20\%$ of the world's population experiences disability, making disabled people the world's largest minority group [1]. Accessible design is, therefore, a critical part of engineering education and training, but is often neglected in early engineering experiences and relegated to graduate-level or elective classes at the university level due to curriculum pressure. Assistive technology design and principles, similarly, are rarely taught in elementary, secondary, or even undergraduate courses. However, the principles of assistive robotics are not complex—they are comprehensible to even the youngest students, and may be more interesting to female students than "classical" introductory robotics projects [2]. Our work is not the first to identify this connection and use assistive design to engage students, but the majority of these curricula focus on a charity model [3] of assistive technology. Instead, we use what we call the "access needs model" of accessibility (Section 2.6).

We propose a a novel structure for introducing design principles for do-it-yourself assistive technology (DIY-AT) [4] at the K-12 level through a co-curricular assistive robotics workshop. In our workshop, students learn technical skills for building robots, and simultaneously learn about accessibility and user-centered DIY-AT design. We conducted a study of participants in a full-day instance of this workshop that we co-hosted with a local Girl Scout organization, integrated with the learning objectives of the Robotics-themed badges for different age groups. Our playful design workshop features open-ended, child-led projects designing assistive robotics for themselves, centering the idea of both assistive technology and assistive technology *design* as tools for empowering users of assistive technology.

Using pre- and post-workshop surveys of the children and chaperones who attended, observations during the workshop, and analysis of whole-group and small group work products, we found that even in a short (single day) interaction, our workshop resulted in changes in self-ratings of both children's knowledge about accessibility and assistive technology *and* the knowledge of their caregivers, even though the workshop was only indirectly targeting caregiver/chaperone education. The child participants also show an increase in their self-reporting about STEM identity as well as their self-reported knowledge about robotics. Through the artifacts of their workshop participation, participants demonstrated understanding of the basic premises of robotics, of the "access needs" model of disability, and how everyday objects can bridge access gaps and become assistive technology even for those who do not identify as disabled.

2 Background

2.1 Playful Engineering

The learning-by-doing model of engineering education has its roots in 20th century theories about learning. In particular, in constructivism, which asserts that knowledge is not transmitted but constructed in students' minds [5], and constructionism, which asserts that this is most easily done when students are engaged in creating physical artifacts [6]. In the wake of those theories and the revolution in education they precipitated, hands-on, open-ended robotics problems have been used to motivate STEM education working both directly with elementary school students [7, 8], and in teacher education workshops. [9] Researchers have found that robotics programs with open-ended problems promote creativity as well as developing scientific principles, a critical skill for professional engineers [10]. The hallmark of this creativity is "solution diversity" [11] in the projects developed.

Outreach programs for playful STEM education [12] have been used to engage with "exhausted" teachers to engage students in the wake of CoViD pandemic learning losses and prevent the elimination of hands-on STEM learning, to improve student engagement with literature [13], to bring both high and low-tech makerspace-based STEM education to low-resource communities [14], and to engage across cultural boundaries, such as bringing robotics education to an inter-generational Diné community [15]. In our work, we use similar principles to teach both principles of basic robotics and of assistive technology through playful engineering and design. In addition, we observe that the principles of playful engineering and its flexibility in engaging students across cultural and socioeconomic barriers also extends to engaging students across disability barriers, making it an excellent choice to pair with the creation of DIY assistive technology.

2.2 Co-Curricular Engineering Education

Despite the utility of playful engineering in the classroom in developing STEM skills, the pressures of standards-based evaluation systems in public K-12 schools [16] and of the need for ever-increasing amounts of technical content in university programs [17] can make it difficult to incorporate these tools. Co-curricular activities can bridge the gap and make playful STEM education techniques available to more students. Hands-on engineering projects and co-curricular activities also promote the development of non-technical skills like task persistence, independence, and collaboration [18, 19] which are critical to engineering success. Our approach uses a co-curricular workshop and ties into an existing co-curricular organization to teach outside the standard curriculum and across age groups, including adult community members learning alongside their children.

2.3 Disability Justice for Accessible Accessibility

User-centered design methodology and movements like Disability Justice [20] argue that disabled voices need to be present in assistive technology design. Despite research recommending that accessibility research be conducted by mixed teams of disabled and non-disabled researchers, most teams of assistive technology researchers do not include disabled researchers [21, 22]. Limited user input is correlated with end-user rejection of technology [23]. To address these gaps, hackathons have been used to incorporate user-centered design and its intersection with topics such as disability [24, 25] and maternal and infant health [26].

While there is limited academic work on teaching assistive design principles to children, there are many examples of workshops designed to teach engineering via assistive design. For example, the GSUSA Cadette "Think Like an Engineer" Journey includes designing a prosthetic for an elephant and a life vest for a dog [27], and the LEGO Engineering assistive robotics module has middle-schoolers design, build, and program "a LEGO robot that could work as an assistive device for the physically challenged population"[28]. To the best of our knowledge, however, none of these workshops incorporate user-empowering design[29] or assume that the disabled client might be an engineer and an active participant in the design process. This omission has concerning implications for the experience of participants who themselves have disabilities, a number estimated at between 15% and 20% of the school-age population. [30, 19]

Prior work does include workshops designed to incorporate the feedback of children in assistive technology design[31, 32, 33, 34] and has explored the challenges of DIY-AT[4] designed for children by their parents and care teams[35], but did not include teaching children about the design of DIY-AT themselves. Our workshop incorporates teaching the children directly about DIY-AT and positions them as the experts in their own needs, empowering them with developmentally appropriate tools to prototype their own designs.

2.4 Belonging and STEM Identity

Work in engineering education has shown that students' sense of belonging, especially in introductory STEM classes, is critical to developing socio-academic relationships crucial to later success in engineering [36]. This sense of belonging contributes directly to the formation of engineering identities for undergraduates [37] and middle-grade students [38] and improves their ability to think about and plan for their future careers. Research also suggests that there can be evolution of identity (both STEM identities and disability, queer, or other identities) in participatory design workshops [39], for researchers, participants, and bystanders, although in that case the change came in the context of multi-session workshops over an extended duration. Educational interventions to address the gender disparity in STEM fields suggests that developmentally-appropriate robotics curricula can increase girls' interest in engineering [40], as well as feelings of belonging which are highly correlated with success in academic programs at the university level [36].

A 2021 review of multiple studies of educational robotics at the pre-college level found that girls were more likely to be interested in robotics projects "which helps humans or animals", where boys were more likely to express interest in "fighting robots" or industrial robot projects [2]. Through our collaboration, we particularly targeted female children and their caregivers, and we intentionally included engaging and dynamic female researchers and engineering students in our workshop as role models for the children. Our workshop focused on assistive robots, defining them broadly as "robots that help people". This connects the interest in helping observed among female students in prior research with one of the foundational ethical principles of the Girl Scouts to "help other people at all times", and with the research team's interest and work in DIY assistive robotics and user-centered design. Though this, we aim to increase participants' identification with STEM knowledge, accessibility and assistive technology knowledge, and STEM identity, as well as their interest in engineering and assistive robotics careers.

2.5 Girl Scouts of the USA

The Girl Scouts of the USA (GSUSA) is a non-governmental organization primarily in the United States that facilitates co-curricular, volunteer-led activities for girls in small groups called "Troops". Girl Scouts are divided into levels based on their grade in school.

The curriculum designed by the Girl Scouts is aimed at developing "girls of courage, confidence, and character who make the world a better place" [41]. Girl Scouts can earn "badges" at their level which they wear on their uniforms, and which serve as certificates recognizing their age-appropriate mastery of a skill. Girl Scouts of the USA currently publishes a set of three Robotics badges for each of the six Girl Scout levels, which are listed in Appendix B.

2.6 The Access Needs Model

Our workshop is motivated by the belief that the best team to solve accessibility problems is one where disabled people and others who need access are centered — not just as a clients *but as the primary designers and builders of the system* [29]. In addition, we assert that assistive technology is for everyone: many people who do not identify as disabled [42] might encounter barriers [43] which limit their access. Furthermore, our workshop is designed to emphasize that tools developed for and by people who identify as disabled in one arena can be useful to people with other disabilities or those outside the disabled community, and to encourage solidarity [20] among all who experience limitations in their daily lives.

Our workshop intentionally does not ask the children to declare a disability identity or separate engineers who identify as disabled from other engineers. Instead, we introduce the "medical" and "social" models of disability [3], and contrast them with what we call the "access needs" model:

People may or may not identify as disabled still have barriers (physical, information, social, cultural, racial, socioeconomic, etc.) which limit their access to places, activities, information, or experiences. We call these "access needs" and use that language to separate disability identity, diagnosis, or other classifications from the identification and dismantling of barriers to access.

This model is designed to emphasize that tools developed for and by people who experience access needs in one arena can be useful to people with other disabilities or outside the disabled community, and to encourage solidarity among all who experience limitations in their daily lives. The access needs model aligns with the principles of *interdependence* [44] by encouraging the formation of design team where each of the members bring different skills and may have different experiences with the access need they are addressing.

Using an "access needs" model of disability, our workshop explicitly invited the participants to consider their own access needs, and design around those, or to work with another person whose access needs became the center of the project. Workshop participants were invited to identify their own access needs (Section 4.2.2) and then form a team with other participants (who may or may not share those access needs but who are interested in addressing the same challenge and bring complementary skills to the team) to develop a prototype.

By starting with DIY-AT and asking participants to design for themselves or someone in their group, they practice centering the voices of the person who experiences the access need in the design process while empowering both the person with the access need and the other participants as engineers in a collaborative effort.

3 Methodology

42 children attended the workshop with their adult chaperones, with 28 children and 8 adult chaperones completing consent forms for the study. Study participants were asked for consent prior to the event (parent/guardian consent in the case of minors) and then children whose guardians had consented on their behalf were asked for their assent prior to the event and as part of each survey. Table 1 breaks down the age ranges of the study participants. We did not collect gender identity, disability status, or age information (other than Girl Scout level) for any participants, but all child participants were registered members of GSUSA, which is open to female and non-binary children in the USA in Kindergarten through 12th grade (approximately ages 5-18).

3.1 Study Approval and Consent Process

Our study was approved by the Institutional Review Board of Tufts University (IRB Study 5625) as an overlay to the workshop itself, meaning that the choice to participate (or not to participate) in any part of the study could not affect participation in the workshop. Study participants were recruited exclusively from among workshop attendees.

In addition, because the study included children ages 5-17, child study participation required consent from a parent or guardian and assent was required from the child participant. Consent for

Table 1: Workshop participants and study participants by Girl Scout level. Section 3.1 explains our recruiting methodology and differences in participant counts for the various study instruments.

Level	Workshop	Study Consent	Pre-Survey	Post-Survey
Daisy (Grades K-1)	1	1	1	0
Brownie (Grades 2-3)	25	17	10	5
Junior (Grades 4-5)	11	5	3	0
Cadette (Grades 6-8)	2	2	2	1
Senior (Grades 9-10)	3	3	3	3
Ambassador (Grades 11-12)	0	0	0	0
Adult	> 10	8	6	6
Total	**51**	**36**	**25**	**15**

adult participants and parent/guardian consent on behalf of children was obtained in advance of exposure to any study instruments and persisted for the full study.

To ethically obtain assent from young children, we determined that verbal or written assent (as appropriate) would be required at every point of interaction between the child and the study. We obtained written assent from children (with the assistance of an adult for pre-literate children) for the pre- and post- surveys, and then verbal assent to participate in the study upon arriving at the workshop (at check-in), and at any point where an observer was asking them a question, asking to see some part of their work, or taking a photograph of them or their work. Those who did not consent to the study fully participated in the workshop but were not formally observed and any photographs of those participants or their projects were not included in the post-workshop analysis. A separate photo release was used to obtain permission for photographs for publicity or study purposes, and only participants who agreed to both the photo release and the study consent (and assent at the moment of capture) have photographs of their work used in the study.

3.2 Workshop Design

The workshop was designed to balance multiple goals:

- Introducing robotics using assistive robotics
- Encourage participation by satisfying Girl Scout badge requirements
- Teach DIY Assistive Design for All to a diverse K-12 group of children and their adult chaperones
- Encourage the formation of interdependent teams with shared goals
- Encourage interest in robotics and STEM broadly, and the development of a STEM identity in girls attending the workshop by presenting them with female role models (faculty, graduate and undergraduate students) in positions of leadership in STEM

The workshop goals concerning learning and identity inspired our research questions, which are presented in Section 3.4, while the goals themselves are presented in more detail below:

3.2.1 Introduce Robotics using Assistive Robotics and Playful Engineering

The first goal of the workshop was to engage with girls with a wide range of exposure to robotics and over a wide range of ages and provide them a positive interaction with assistive robotics and engineering. In order to facilitate this, we used two robot platforms specifically designed for children who may have little or no prior robotics experience [45], but with the capability to be used in very advanced ways by more experienced users [46]. We also included programming and robotics-based games, a slideshow with photos and videos of a wide variety of different types of commercial and research robots, and tours of university labs with demonstrations of assistive robotics and Human-Robot Interaction research.

Our workshop intentionally did not include any direct instruction on how to use the two different robot platforms. Instead, workshop participants were encouraged to experiment, iterate, and ask for help as needed, in accordance with our choice of a "playful engineering" methodology [14]. The ten lab assistants had prior experience with one or both of the robot platforms, and were all given a one-hour training prior to the workshop to ensure they could support the needs of the participants.

3.2.2 Satisfy Girl Scout Badge Requirements

To motivate attendance at the workshop for both Girl Scouts and their caregivers, the workshop was designed explicitly to cover all the activities required to earn at least one badge from the three-badge Robotics sets available for each level. A mapping of workshop contents to robotics badge requirements is in Appendix B, Table 5.

Badges that were completed during the workshop were purchased by our Girl Scout Service Unit partner and were awarded at the completion of the workshop.

3.2.3 Teach DIY Assistive Design for All

In order to include both participants who identify as disabled and those who do not, and to make our work accessible to children as young as 5, we defined assistive technology very broadly and in simple language: *Assistive Technology is stuff people make (technology) that helps people (assists them) to do things*. From this, we briefly introduced assistive robotics (using the example of a Kinova JACO robotic arm attached to a power wheelchair) as *robots that help people*. We asked the children to collectively brainstorm the answers to the question "What are examples of a disability?" (Section 4.2.1) before briefly introducing a simplified version of the medical and social models of disability [23, 47] and the idea of access needs (Section 2.6) as orthogonal and separate from a medical diagnosis or disability identity.

We shared with the workshop attendees our philosophical take on assistive design:
Who makes Assistive Technology and Who Uses It?

- Assistive technology is not just for people with official disabilities—everyone has access needs.
- You do not need to be an expert to make assistive technology: everyone brings skills that can contribute to solutions.

- The person who needs the help is the expert: they know about the problem and can tell if the solution works.

3.2.4 Assistive Design and Interdependent Teams

To introduce the idea of DIY assistive technology [4], we asked participants to share access needs they have personally experienced that a robot could help with, and to brainstorm together examples of assistive technology that would help (Section 4.2.2). This brainstorming led directly into the primary workshop activity: participants were asked to come up with with an idea for a robot prototype that would assist themselves or someone in their group, form a team with people also interested in the same challenge with skills that complement their own, and create a prototype of their idea, iteratively sharing it and improving it over the course of several hours.

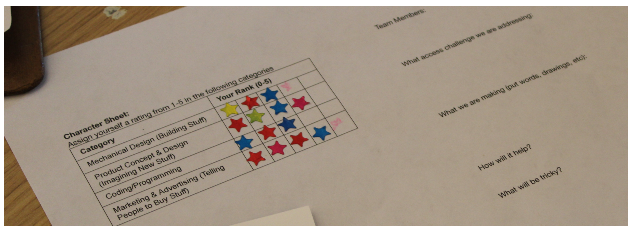


Figure 1: "Character Sheet" tool for team-formation. Participants were encouraged to make teams with members with complementary skills.

The workshop aimed to support an interdependence model by forming teams of participants with common interests and complementary skills. However, we found that in a single-day workshop format with participants who knew some but not all the other participants, this team formation was difficult (see section 5.5).

3.2.5 Encourage interest in robotics and STEM by presenting strong female role models (Positionality)

The workshop was designed and led by the first author, a disabled, Indigenous American female doctoral student in Mechanical Engineering and Human-Robot Interaction who is also a Girl Scout volunteer, and by the last author, a disabled white American female faculty member in Computer Science. Workshop and study staff included five female and five male student lab assistants, three of whom identify as BIPOC, and all of whom were engineering students at the undergraduate, graduate, or doctoral level with an interest in assistive robotics, STEM education, or both.

The workshop organizers and volunteers actively engaged directly with the participants across the entire workshop, presenting activities and leading tours as well as directly assisting the participants with technical support for their projects and in presenting them to the workshop. Through this structure and workshop leadership, we introduced the participants to diverse working roboticists and researchers. By collaborating with the children on technical work and positioning the children as junior colleagues, we include them in the community of working engineers.

3.3 Workshop Structure

The workshop was structured as a full-day event: it began with a slideshow with pictures and videos of bio-inspired and assistive robots, interspersed with brainstorming/collaboration questions:

- What is a robot? (individual answer, draw or write)
- What is a robot? (repeated after defining a robot via the Observe-Think-Act model [48], to suggest expanding their definition of robots)
- What are examples of disability? (wordcloud group activity using Mentimeter)
- What kind of access needs have you had? (group activity with anonymous answers shared via Mentimeter)
- What are examples of Assistive Technology? (wordcloud group activity using Mentimeter)

The attendees were then invited to make teams and create a prototype of an assistive robot that would help them or someone else on their team with an access need they experience.

The teams were given access to two types of robotic platforms to create their prototypes:

- LEGO SPIKE Prime [49]
- Smart Motors [45]

as well as access to craft supplies and recycled materials. Participants were encouraged to experiment and to ask the workshop staff for help if needed, and had access to both the built-in Heart Program of the LEGO SPIKE Prime and the LEGO SPIKE Prime website (`https://spike.legoeducation.com/prime/project`) if they needed access to more advanced programming options.

The morning session wrapped up with team formation and initial design work. Participants were given a "character sheet" (Figure 1) to rate their own skill in different aspects of robot creation. Participants created their character sheets via self-assessment with minimal guidance as to ranking scales. The character sheet also included an area to write personal notes about team formation and project formation information in the next step. Next, any participants with an idea for an assistive robot were asked to create a one-line "project pitch" and put it on large sticky-backed papers in different places around the room. The other participants were asked to browse the posted ideas and talk with the team captains. Workshop facilitators and lab assistants, as well as adult chaperones, supported the Girl Scouts in matching up teams with others who shared an interest in their project and who had complementary skills to their own.

The afternoon part of the workshop began with a game about programming robots, where groups of children navigated a "robot" played by a lab assistant or one of the Senior Girl Scouts around the room to a target they selected with a limited vocabulary of actions. The rest of the afternoon was dedicated to building and iteration—groups were encouraged to share their designs informally with other groups and with the lab assistants and get feedback on how to improve their design several times during the afternoon session. Groups of Girl Scouts and their chaperones were also pulled out of the workshop in the afternoon for tours of the human-robot interaction labs and demonstrations of current research by a faculty member and three graduate students.

At the end of the workshop, each group was invited to present their design to the entire group, explain how their assistive technology helped them (or their teammate), how the prototype could be improved, and what tools they would need to develop a higher-fidelity prototype or a commercial product.

3.4 Research Questions and Study Instruments

Of our five workshop goals (Section 3.2), one is functional and was achieved through the design of the workshop activities (satisfy Girl Scout badge requirements), one is operational (encouraging the formation of interdependent teams), two are educational, and one focuses on identity. Our research questions focus on the latter three goals:

- **RQ1:** Will our assistive robotics workshop teach K-12 children with little or no robotics experience about robots in a way that they find engaging?
- **RQ2:** Will our workshop teach K-12 children with little or no prior experience in accessibility or assistive technology about the principles of assistive technology and how to develop it?
- **RQ3:** Will our female-led workshop in assistive robotics and computer science will encourage girls to be more interested in STEM and robotics and support them building a STEM identity?

We were also interested in the phenomenon of inter-generational learning environments, where adults learn alongside their children [50, 51], and added an additional research question to look at the effect of workshop participation on the attending adult chaperones:

- **RQ4:** Will adult chaperones attending the workshop alongside the child participants **also** learn about assistive robotics and accessibility? Will their STEM identity change as part of this exposure?

To test our hypotheses, we used pre- and post-workshop surveys, as well as observations conducted by facilitators and post-hoc analysis of workshop artifacts to identify identity-building, empathy-building, and knowledge-building activities.

Our pre-event survey (Appendix A.1) asked participants about their familiarity with robotics, their familiarity with accessibility or assistive technology, and whether they identify as an engineer or "STEM person", with an open-response to explain why or why not.

Our post-event survey (Appendix A.2) explicitly asked participants to re-answer how much they knew before the workshop about each topic and invited them to compare that to their knowledge after the workshop, with open-response questions to discuss what they learned. It repeated the question about STEM identity, and added a question about whether they would like to learn more about any of the covered topics. A final section of the post-survey invited general feedback on the workshop in a five-question set.

In addition, observers during the event used an observation worksheet (Appendix A.3) to take notes about the study participants as they engaged with the materials and the university student volunteers serving as lab assistants. Because all parts of the study were optional for workshop participants, not every participant completed all study tools; a breakdown of the participation in each tool is also included in Table 1. Surveys which contained no responses to survey questions were discarded (2 from the pre-survey, 1 from the post-survey) and are not included in the table. All surveys and consent forms were offered in English or translated into Spanish by a professional translator, and available on paper at the workshop or before and after (as appropriate) via Qualtrics.

4 Results

For each of our three main questions **RQ1, RQ2,** and **RQ3**, we compare the quantitative sections of the pre- and post-event surveys to identify trends for all respondents. In each section, we present both the full set of pre- and post-workshop survey responses, and a comparison of just the respondents to each question who participated in both surveys. In addition, the responses to the six free-text sections of the post-event survey (Appendix A.2) are collected, categorized, and included in the relevant sections, and an analysis of the responses from the single free-text question on the pre-event survey are included in Section 4.4). Analysis of relevant study artifacts (projects built by participants, answers to group brainstorming questions) is also included in the sections for each participant.

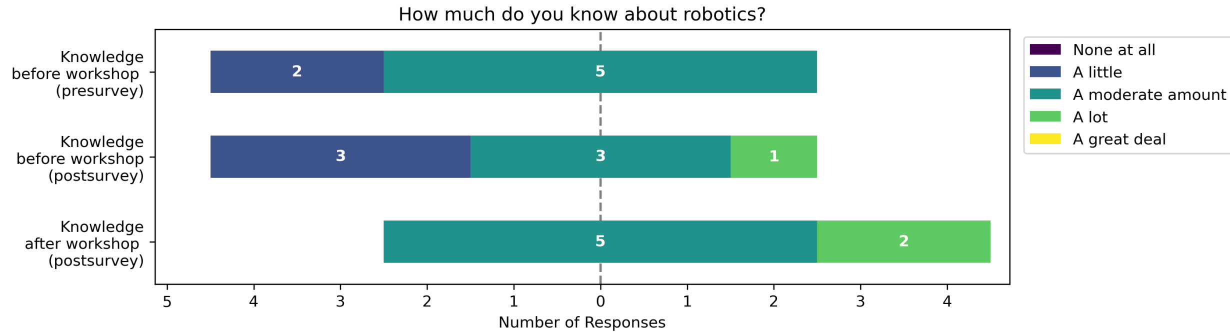
RQ4 is included as a separate section with analysis of the adult survey respondents.

4.1 Research Question 1: Robotics Knowledge

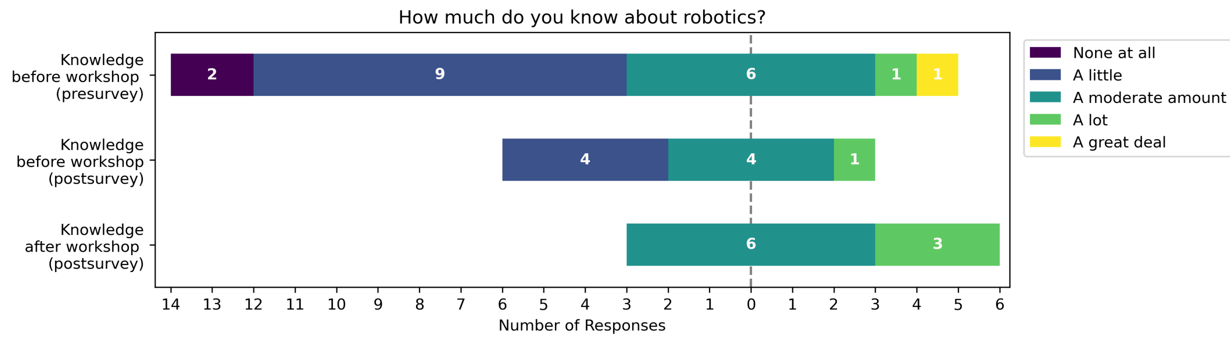
We asked participants to rank their knowledge prior to the workshop on both the pre- and post-workshop surveys. Figure 2 gives a visualization of the responses from the pre- and post-surveys. While some participants did change their answers about their knowledge prior to the workshop between the pre-workshop and post-workshop surveys, the difference between the two reports of pre-workshop knowledge was not statistically significant.

Due to the large differences in sample sizes between the pre-workshop and post-workshop surveys, we used a two-group difference-in-means randomization test with $20,000$ replications [52] to compare the answers to the pre-workshop survey question to "How much do you know about robotics?" with the post-workshop survey answers to "How much do you know about robotics now?". The mean robotics knowledge of the child participants increased with a difference-in-means of 1.0 levels ($p = 0.0015$). For child participants who completed both surveys, the mean robotics knowledge increased in a marginally significant way with a difference-in-means of 0.57 levels ($p = 0.07$).

Looking individually at the participants, of the nine who completed the post-workshop survey (5 Brownies, 1 Cadette, 3 Seniors), all but one Senior-age participant reported an increase in their knowledge over the course of the workshop on the post-workshop survey, while that Senior reported no change. One of the participants who completed both surveys ranked their knowledge on the pre-survey more highly than they ranked their knowledge before the workshop, while the other five were consistent. Of the 12 participants (1 Daisy, 7 Brownie, 1 Cadette, 3 Juniors) who only completed the pre-survey, 2 said they had no knowledge of robotics, 7 ranked themselves as having a little knowledge, 1 a moderate amount, and 1 a great deal of knowledge.



(a) Responses for child participants who completed both surveys (7 participants).



(b) Responses for child participants who completed either survey (19 presurvey, 9 postsurvey)

Figure 2: Robotics Knowledge: Children's survey responses. The 0 line indicates the midpoint of the neutral response ("A moderate amount"), and the x-axis the number of negative or positive valence responses.

4.1.1 RQ1: Workshop Artifacts and survey free-text responses

During the workshop, participants were asked to write or draw their answer to "What is a robot?" before and after our discussion of the Observe-Think-Act model. Figure 3 shows one example of these notes shared with the research team, which is representative of many of the reflections from the workshop.

In this (Figure 3) example, there is a progression: Before our discussion of what robots are, the student visualizes a robot as an anthropomorphic construct that is "not live" (not alive) and "helps people". Her drawing reflects this description, showing the robot as a mechanical person—clearly artificial, but also clearly person-like.

In her description after the discussion of the essential features of a robot (the sense-think-act model), her description is more broad, including the word "electronic" and the idea that robots are programmed—that people had to teach robots to do what they do.

In other post-discussion writing, several students mentioned robots having "senses" (or sensors), and being "computers that can move", and that they can "be programmed to do whatever you want".

In the post-workshop survey, child participants elaborated on these themes: they were excited to

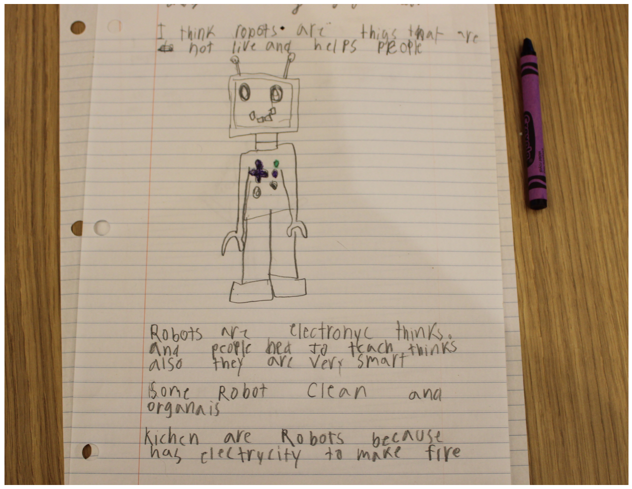


Figure 3: Example participant drawing and notes from the participation question "What is a robot?". Children were asked first to write down their ideas before the facilitator gave the definition of a robot, and then to write down any new ideas after being introduced to the "Observe-Think-Act" model for robotics.

PID	GS Level	Pre-Survey	Post: Knew Before	Post: Know After
G2	Cadette	A moderate amount (3)	A lot (4)	A lot (4)
G7	Brownie	None at all (1)	None at all (1)	A little (2)
G29	Senior	A moderate amount (3)	A moderate amount (3)	A lot (4)
G30	Brownie	A little (2)	None at all (1)	A moderate amount(3)
G33	Senior	A moderate amount (3)	A moderate amount (3)	A moderate amount (3)
G34	Senior	A moderate amount (3)	A moderate amount (3)	A lot (4)

Table 2: Individual accessibility self-reported knowledge for children who completed both surveys

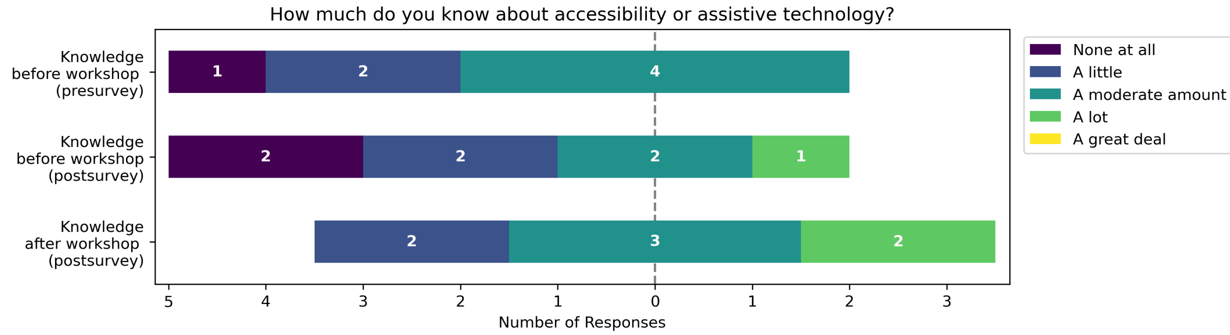
have learned about particular types of robots, that robots come in many different forms and sizes (including LEGO).

4.2 RQ2: Understanding of Accessibility and Assistive Technology

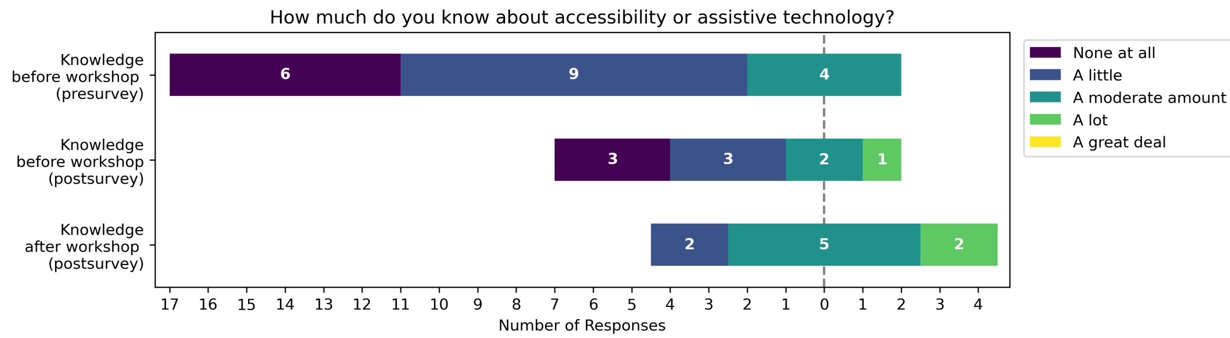
In our surveys, we asked participants before the workshop about their familiarity with accessibility or assistive technology, and then asked them in the post-workshop survey about their knowledge before and after the workshop. In addition to the survey questions about accessibility, we present the results of three group-participation questions about aspects of disability and accessibility.

Figure 4 compares the child participants who completed both surveys (Figure 4 a) and the full set of child participants who took either survey (Figure 4 b). For the full set of child participants, accessibility knowledge increased by almost a full level, and the difference in the ratings was significant (in a 20,000 replication two-sample randomization test [52]) with a difference of means of 1.89 ($p = 0.0003$). For just the child participants who took both surveys, the there is a marginally significant increase with a mean difference of 0.57 ($p = 0.11635$).

Looking individually at accessibility knowledge of participants (Table 2), 5 reported an increase



(a) Survey responses, only for child participants who completed both surveys (7 participants).



(b) Responses for child participants who completed either survey (19 presurvey, 9 postsurvey)

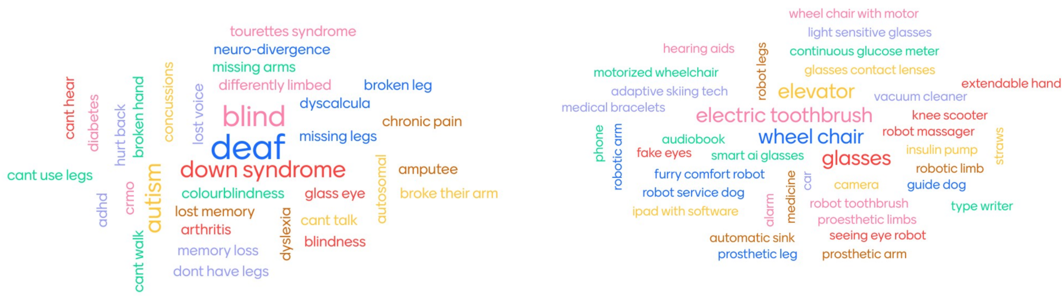
Figure 4: Survey Responses to ”How much do you know about accessibility or assistive technology?” The 0 line indicates the midpoint of the neutral response (“A moderate amount”), and the x-axis the number of negative or positive valence responses.

in their knowledge of assistive technology, including 2 who reported a change from “none at all” to “a moderate amount”, while three reported no changes, and one reported that they believed they knew less about accessibility after the workshop. Two child participants changed their answer about their pre-workshop knowledge between the two surveys: one from “a little” to “none at all”, and one from “a moderate amount” to “a lot”.

4.2.1 RQ2: Group Brainstorming: What are examples of a disability?

This group brainstorming question was asked in the workshop near the end of our introductory slides. We asked the participants to send in their answers to the question “What are examples of a disability?” via Mentimeter [53], which collects answers anonymously and creates a wordcloud of the responses (Figure 5a).

The responses (categorized in Table 3) include both commonly-known disabilities such as limb differences, mobility impairments, deafness, and vision impairments, as well as invisible disabilities such as neurodivergence, brain injuries, chronic pain conditions, and developmental and learning disorders. Seventeen different “respondents” submitted 41 answers to the question. (Some respondents represent tables of adult and child participants, who were discussing as a group and submitting their answers together on an adult’s or lab assistant’s phone or tablet).



(a) "What are examples of a disability?"

(b) "What are examples of assistive technology?"

Figure 5: Wordclouds generated during the workshop and immediately shared with participants in response to prompts

Table 3: Categorization of workshop participants' answers to "What are examples of a disability?"

Category	**Responses in Category**
Physical Disabilities	19
Temporary Injuries	4
Neurodivergence	4
Cognitive impairments	3
Developmental Disorders	6
Autoimmune Disorders	4

4.2.2 RQ2: Group Brainstorming: What access needs have you had that a robot could help with?

Nineteen responses were recorded from nineteen different respondents (again, sometimes representing a group of participants seated at the same table), with thirty-four separate answers within the responses (some responses included a list of answers). We performed a qualitative analysis on the responses for this question, first grouping them and then, based on the initial groupings, categorizing them by access need filled and type of support.

Of the 34 responses, 13 were related to reaching things that were out of reach, either because they were too high (an example used in the workshop introduction) or because something is in the way. Six of the responses involved transportation, four involved locating things or people, and two suggested robots that would help with ecological issues. Twenty of the robots provided some sort of physical support, eight provided information to the user, two provided mental support, and two provided social support.

4.2.3 Group Brainstorming: What are examples of assistive technology?

Our final group brainstorming activity asked the participants to share examples of assistive technology. The generated wordcloud (Figure 5b) was shared with participants. Of the 44 responses, fourteen were classified post-hoc by the research team as "everyday items" such as an elevator, car, phone, straws, alarms, audiobooks, or an electric toothbrush. Ten related to classic or stereotypical assistive technologies like wheelchairs, guide dogs, or prosthetic limbs, ten to medical technology like glasses, continuous glucose monitors, or hearing aids, and seven were classified as assistive robots like a robot service dog, robotic arm, or furry comfort robot.

4.2.4 RQ2: Free Text Survey Questions

In our post-event survey, participants were asked to share what they learned about assistive technology.

Child respondents gave examples both of specific assistive technologies like a wheelchair and broad categories. One said, "You can use robots to make you get taller, shorter, and maybe see better, and help you know where you're going"(G30). One responded that they learned that "Assistive tech can help people who don't normally think of themselves as disabled"(G33).

4.3 RQ1 and RQ2: DIY Assistive Technology Creations

In total, ten projects were proposed and eight projects were completed among the participants in the workshop who also consented to being part of the study. (Additional projects were proposed and completed but not documented, as not all of the members of their teams were participating in the study.) Table 4 has the ten projects, and references to images of the projects as-available. Only images of participants/their projects with both a study consent form and a photo release on file are included. Both of the projects which were proposed and not completed were identified as too difficult to prototype with the available materials—the project champions for those two projects joined other teams.

The diverse projects created in the workshop showcase both the participants' understanding of basic principles of robotics (using various types of sensors to actuate mechanisms in the robot for particular effects), the solution diversity characteristic of Playful Engineering pedagogy, and the participants' understanding of the assistive technology principles presented in the workshop. Participants created projects about which they felt passionate, presenting them to the gathered group of over 50 people and explaining how these robots assisted them in their daily lives, demonstrating an understanding of the "access needs" model.

4.4 Research Question 3: STEM Identity

We measured STEM identity primarily through our pre- and post-workshop surveys, via both the Likert and free-text questions.

Figure 8 presents the child responses, grouped by those who participated in both surveys and the full set of participants in either survey.

Among the child respondents, three of the negative-valence responses on the pre-workshop survey question about STEM identity ("Definitely not" and "Probably not") noted that they have little or no experience with robotics or math as an explanation for their lack of STEM identity. One respondent stated "I don't want to be an engineer"(G25), and another noted "I like it a little bit but I'm not sure I love it"(G3).

Table 4: Selection of Project Proposals (Team-Building Phase)

Project Proposed	**Project Built?**
Robot to find things and go get them	Yes
Table Robot to come to you when you need it	Yes
Epi Pen Robot	No
Colorblindness Support Robot	Yes (Figure 6)
Smart Reading Lamp	Yes
Guardian Robot	Yes
Claw Robot to reach things	Yes
Reaching Robot	Yes
Animal Robot to keep you company	Yes (Figure 7 and multiple other robots)
Leg Extensions to reach things up high	No

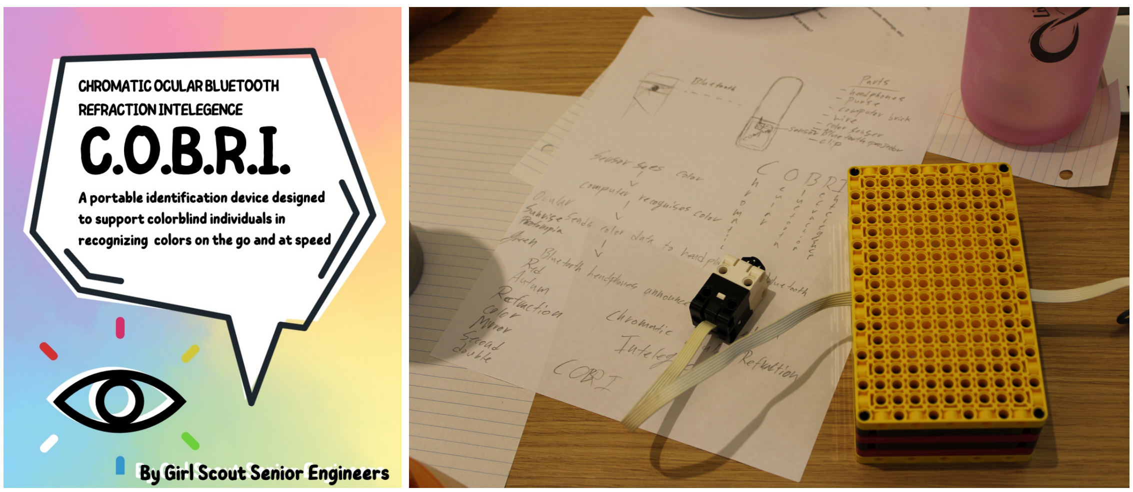


Figure 6: Example of an assistive robot and advertisement for the robot, designed by and for one of the workshop participants in collaboration with her two teammates. The robot is designed to fit in a pocket or purse, and was inspired by one of the designers' own experience with colorblindness.

Of the neutral responses on the same question, ("Might or might not"), four of the five respondents who provided text explanations gave their lack of experience or knowledge as a reason ("I don't think I know enough to count yet"(G33)). The "probably yes" responses both indicated that enjoying doing STEM activities (science, math, making things) was why they identify as an engineer or STEM person(G2, G34) and were both older girls (Cadette and Senior).

In our post-survey, we did not explicitly ask free-text questions about STEM identity, but it did come up in the responses to other questions. For example, in their response to the question about what they learned about robotics, one Brownie level participant noted that "Robots are cool and now I want to study to be a robotic engineer"(G7). In response to "What did you like most?" about the workshop, ten responses related to STEM interest: eight of the children noted that they enjoyed building robots or working on the project, while two adults said their favorite part was seeing the girls "figure out"(A39) the project and "get into"(A6) building their robots. Another noted that the mentorship aspect and the playful engineering structure both really appealed to them: "I really like

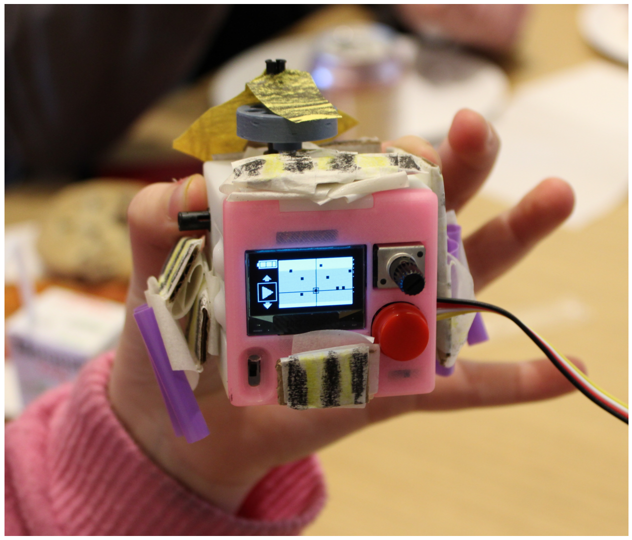


Figure 7: Bee robot built with a SmartMotor “to keep you company, but it can also get things for you from high places”. The inventor applied principles of social robotics as well as assistive robotics to her own needs.

that there were graduate students working with the kids as mentors. I also really like there some opportunities to focus and space to be a little silly”(A38). In the final free-text question, one of the adult participants particularly called out their perceived change in the girls in their care: “You are exposing the girls to STEM before they start to think math is hard. This is huge. At least three girls that attended today from our troop walked away wanting to do more robotics in their future.”(A39)

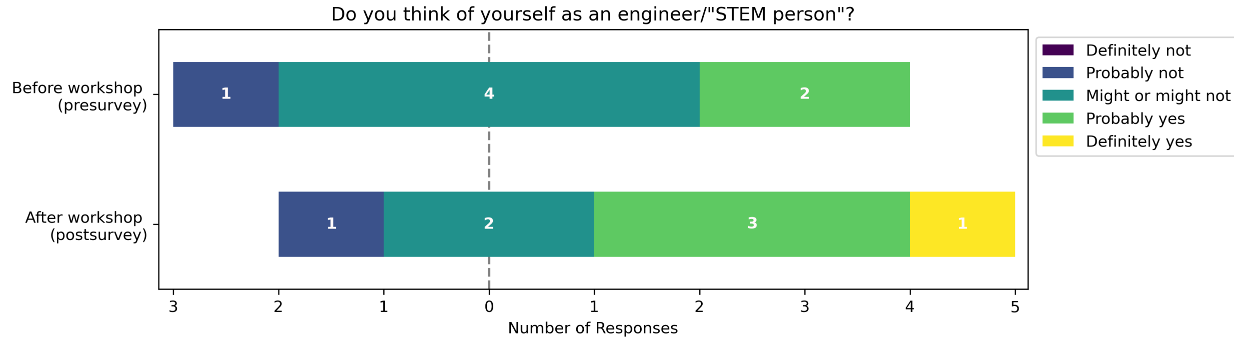
While STEM *interest* is not the same as STEM identity, STEM interest is a precursor indicator and correlated with a STEM identity[54]. In our post-event survey, we asked both children and adults if they were interested in learning more about robotics, engineering, assistive technology or accessibility. Among the children who completed the post-event survey, all but one had positive valence responses (Figure 9).

4.5 RQ4: Adult Knowledge and STEM Identity

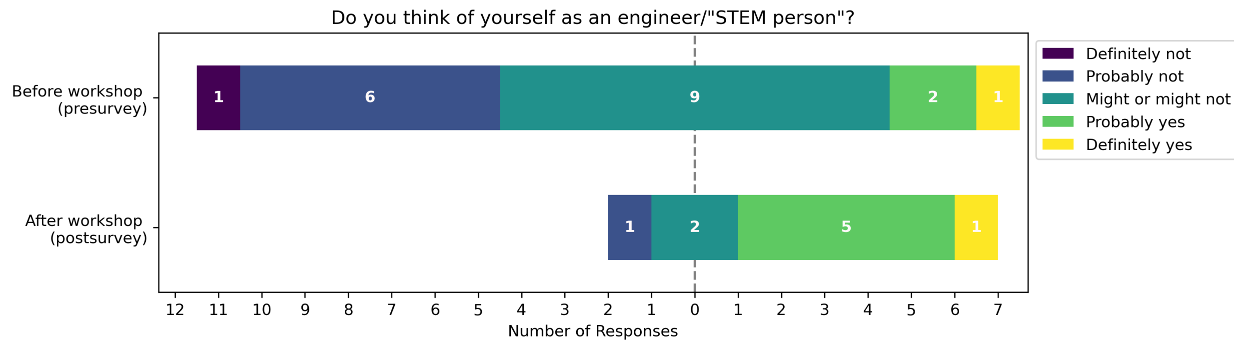
4.5.1 Robotics Knowledge

For adult participants (Figure 10), the difference-in-means of the responses to the question “How much do you know about robotics?” increased by 0.5 levels, but the change was not statistically significant for either the four adults who participated in both surveys $(p = 0.28)$ or between the 6 adults who participated in the pre-workshop survey and the 6 adults who participated in the post-workshop survey $(p = 0.179)$.

Looking at adult survey respondents individually, there are three checkpoints for each participant: their self-report from the pre-survey, and then their self-reports from the post-survey of what they believe they knew before and what they know after the workshop. For the four participants who completed both surveys, one reported the same self-evaluation (“a little”) for all three checkpoints. Two reported the same levels in their post-workshop survey (indicating that they did not perceive



(a) Survey responses, only for child participants who completed both surveys (7 participants).



(b) Responses for child participants who completed either survey (19 presurvey, 9 postsurvey)

Figure 8: Survey Responses to ”Do you think of yourself as an engineer/ “STEM person?””

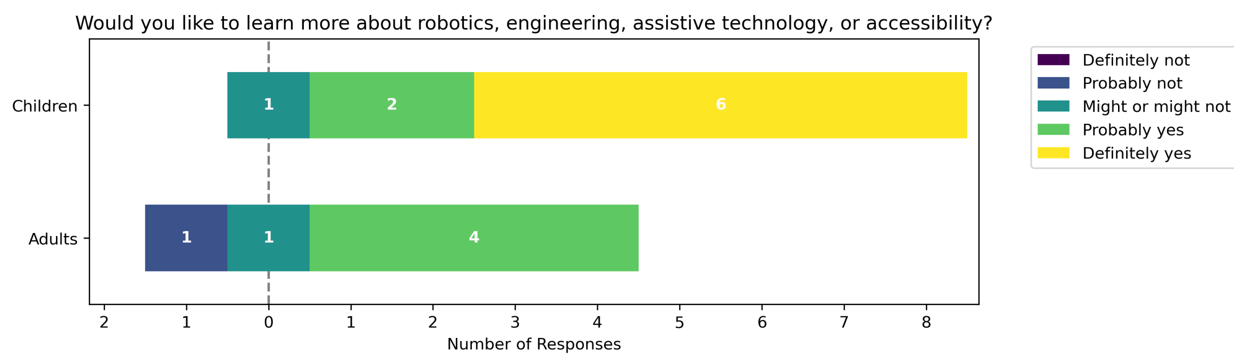


Figure 9: Survey Responses (post-event survey only) to ”Would you like to learn more about robotics, engineering, assistive technology, or accessibility?” The vertical 0 line indicates the center of the neutral response (“might or might not”, and the x-axis the number of negative (left of the 0 line) or positive valence responses (right of the vertical 0 line)

themselves as knowing more after than they had before), but both indicated a higher level of knowledge than they had indicated in the pre-survey. The last participant who completed both surveys indicated the same level of knowledge between the pre-survey and the post-survey, post-workshop, but a lower level for their knowledge pre-workshop on the post-workshop survey. This suggests that they perceived themselves as having learned something significant from the workshop but may have changed their view of the upper limit of the scale.

Among the participants who only completed the post-workshop survey (2 participants), both reported an increase from "a little" to "a moderate amount" over the course of the workshop, suggesting that they also perceive themselves as having learned something about robotics.

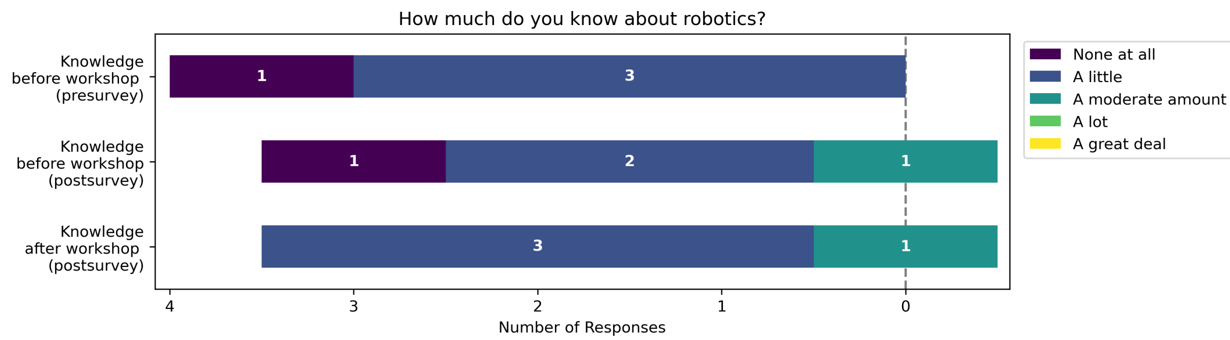


Figure 10: Robotics knowledge of adults who participated in both surveys. The 0 line indicates the midpoint of the neutral response ("A moderate amount"), and the x-axis the number of negative or positive valence responses.

In the free-text responses on the post-workshop survey, adult respondents primarily discussed their surprise at how many different kinds of robots exist, and that "everyday" items can be considered robots.

4.5.2 Adult Knowledge of Assistive Technology

In the post-workshop survey, one adult respondent shared that they learned "That it is not only technology for people with a diagnosed disabilities/divergencies, but encompasses any assistive device"(A6). Another shared that they were surprised to learn that assistive technology is related to making (A38). Another noted that "I didn't learn about real examples of assistive technology but I did think about access needs and assistive devices in a new way"(A40).

In the surveys, the difference in reported accessibility knowledge between the entire adult pre-workshop and adult post-workshop surveys was statistically significant with a difference-in-means of 1.33 ($p = 0.0099$), but the difference for participants who participated in both surveys was not, despite a difference-in-means of 1.00 level ($p = 0.14$), due to the small sample size and wide variance. On the post-workshop survey, the differences reported by adults for their accessibility and assistive technology knowledge before and after the workshop are negligible, with only one participant changing their score between the two questions.

Looking individually at participants, only one adult reported an increase in their knowledge of accessibility before and after the workshop on the post-workshop survey, and one other had an increase between their pre-workshop self-reported knowledge and their post-workshop reported knowledge. The other four adult participants who completed the post-workshop survey reported no change in their knowledge, with one noting in the free text " I feel like I was thinking about the girls and didn't pause to learn as an individual".

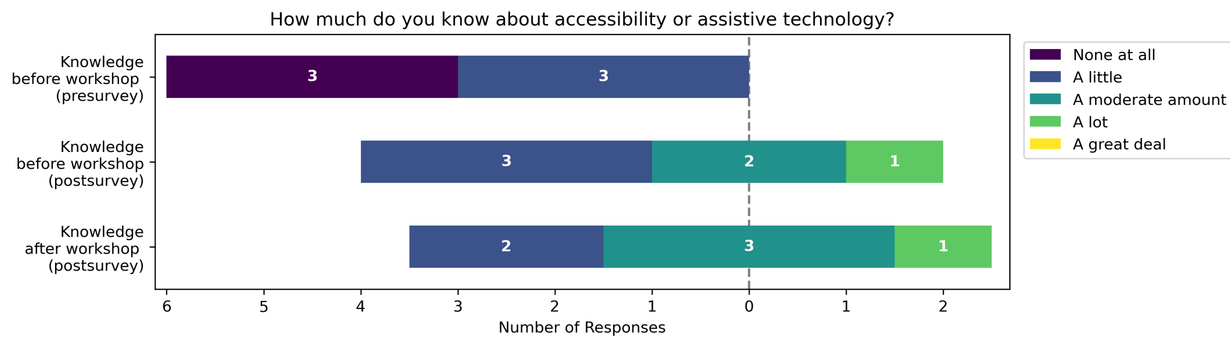


Figure 11: Accessibility and assistive technology knowledge: all adult participants

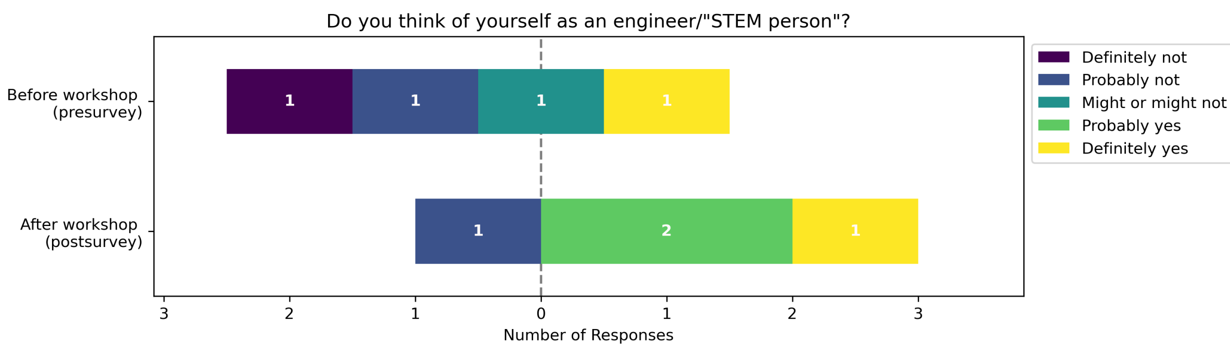


Figure 12: STEM identity in adult participants

4.5.3 Adult STEM Identity

Adult participants who took both surveys reported an increase in STEM identity overall, with two participants increasing their scores by one level (very negative to mildly negative, neutral to mildly positive), one participant increasing their score from mildly negative to mildly positive (2 levels), and one participant maintaining a strongly positive STEM identity (definitely yes), noting that they are a science teacher and their STEM identity is related to their occupation(A6).

In the pre-survey, all of the adult respondents referenced their knowledge or lack of knowledge in explaining their identification with STEM. One participant, who responded “Definitely not”, stated “I like robotics, just haven’t done too much with it”(A41). Another “Definitely not” respondent noted “I never thought of myself as a science/tech person, though I always liked math!”(A40).

However, similarly to the children, most of the adult respondents in the post-survey indicated that they would be interested in learning more (4 of 6 positive-valence responses), with one slighty negative and one neutral response (Figure 9), indicating a STEM interest if not a STEM identity.

5 Discussion

5.1 RQ1: Building Robots that Help People

Children in our workshop increased their knowledge of robotics through our assistive robotics workshop. Both in their self-reported data (Figure 2) and the workshop artifacts and free-text responses on the survey, participants demonstrated new skills and knowledge both about robotics generally and about assistive robotics in particular. Their projects (Figures 6, 7, and Table 4) show a wide range of applications and complexities, from a robot built onto a single SmartMotor to robots built and programmed with multiple LEGO Spike Prime hubs and half a dozen sensors. Participants built a broad technical view of what robots can be—"a robot is a machine with sensors that takes actions"(G33)—but also built a human-centered view of robotics: "Robots are things that are not alive and help people"(G1).

Participants were enthusiastic to share their creations and explain how they work—the creator of the Beebot (Figure 7) excitedly told anyone who would listen "it moves with A.I., but it's not magic I can tell you how it works"(G35), demonstrating new knowledge, pride in that knowledge, and enthusiasm for sharing the new knowledge with others. Other groups showed off how robots using the LEGO SPIKE Prime's default Heart Program could cross the room to retrieve an object, how their block-programmed Smart Lights could support bedtime reading and gentle wake-ups to make the day start and end nicely (G2), or how their color sensor fits invisibly into the purse of a color-blind girl on the team to report the color of nearby objects directly and discretely to her earbuds (Figure 6, G29, G33, and G34). Despite very little or no prior experience with these robotics platforms, or (for many) with any kind of robotics, the workshop participants experimented, iterated, and drew on the lab assistants' expertise to make their imagined assistive robotics a reality.

5.2 Assistive Technology for Everyone

Although we only shared one example of a commercially-available robot that would typically be classified as an "assistive robot", both the girls and adults came away from the workshop with a new perspective on what assistive technology can do and be. We can trace the evolution of their thinking through the group brainstorming exercises: the responses to the first activity (examples of disability) are almost entirely medical problems and more than half are temporary or permanent physical impairments. In contrast, the examples of assistive technology submitted less than 30 minutes later are far more diverse, with many everyday items. The post-workshop survey results support this interpretation, with participants observing that assistive technology can help people who "don't normally think of themselves as disabled"(G33) and that the workshop caused them to "think about access needs and assistive devices in a new way"(A40).

The workshop was also successful in incorporating playful engineering into the design of assistive technology. In the brainstorming activity (Section 4.2.3), in the proposals for projects, and in the final projects that were created, the participants incorporated whimsical robot designs with a very serious commitment to making improvements in the world for themselves and people they know, with a substantial solution diversity.

5.3 STEM Interest and STEM Identity

In our pre-workshop survey, we observe a trend in the free-text responses drawing a differentiation between being a person who enjoys doing things related to science, technology, engineering and/or mathematics and an identity as an engineer or "STEM person". Adult participants drew distinctions between enjoying STEM activities like math, science, or robotics and identifying with STEM. Among the children, the same distinction was observed—those who enjoy STEM activities still may not identify with STEM or as an engineer because they "do not count" due to lack of experience or qualifications. These align with prior work [54] in suggesting that identity is more complex than interest alone (as reflected in the modest changes we observe between the answers to the pre-workshop and post-workshop questions directly asking about STEM identity). However, the high level of interest in learning more about STEM topics in the post-workshop survey suggests that while the participants may not identify as engineers **yet**, they are interested in learning more (Figure 9)—opening the door to the development of a STEM identity as they gain experience.

Several free-text responses from adults suggest that the children left the workshop with new interest in *developing* a STEM identity: one attendee noted that "At least three girls that attended today from our troop walked away wanting to do more robotics in their future"(A39), and another requested that we repeat the workshop at local schools to give more students the same opportunities (A38).

5.4 Adults

Engagement with adult participants varied throughout the workshop. One observer noted that while all adults were listening to the lecture parts of the workshop, some adults were very engaged with the hands-on aspects of the workshop, while others were chatting among themselves and not participating with the children. The survey responses reflect this as well: one participant apologized for not thinking about what they might have learned themselves and "just focusing on the kids". This is also reflected in the modest change in adults' self-reported knowledge about robotics.

However, several adults talked about changing their perspectives about assistive technology (even though most reported not knowing anything more about the topic in the two post-survey questions). These changes in perspective are intriguing; exploring their effects on adults' interactions with assistive technology more broadly is an interesting area for future exploration.

Similarly, while the reported changes in STEM identity for adults were not statistically significant due to the high variance in the data and small sample sizes, the presence of **any** change in identity is intriguing for an adult participant and worth further investigation.

5.5 Limitations and Future Work

There are several areas where future work can improve our understanding of the effectiveness of DIY assistive robotics workshops for teaching about robotics, accessibility and assistive technology, and building STEM identity. First, our study was limited to a single, one-day workshop where study participation was opt-in for each study instrument, leading to relatively small datasets. While this allowed many children to participate in the workshop who might have been excluded if study participation had been required, it limited the power of our analysis.

In addition, the mixed group of study participants and non-study-participants at the workshop prevented us from videotaping the full workshop, making data collection about interpersonal and technical interactions more challenging. While we had planned to capture some of that via the Observation Worksheet (Appendix A.3), the observers were also Lab Assistants, and were often distracted by other workshop tasks, resulting in observation worksheets that were mostly neglected in favor of direct interaction with the workshop participants and did not result in analyzable data. Future work would benefit from both dedicated observers who do not have other roles, and a formal de-briefing of workshop volunteers with time to record observations during workshop breaks.

We also found that we were limited in our ability to analyze growth in both knowledge and identity-building from our short-answer survey questions. Interviews with participants might give more understanding of the ways participants' identity changed and how that might change the way they interact with STEM generally or specifically with assistive technology.

One limitation of our workshop was our inability to provide every participant with a group excited to work with them on their proposed project. While all participants were able to make assistive robots they were excited to share, at least two participants worked primarily on their own and several abandoned their proposed projects to support others. Because some participants attended as solo Girl Scouts and others attending with one or more troop members, the solo Girl Scouts were at a disadvantage in group formation, and the Girl Scouts who attended with those they already knew were reluctant to form groups with those they did not already know using the "character sheet" model, even if girls from other troops might have also had shared interest in their project. Other factors to consider in team formation include identifying participants who may be the only speakers of their primary language in the group, the only participants of their age/Girl Scout level, or the only participants who experience a particular access need, all of which may make it more difficult for them to recruit excited teammates or to complete their projects. Future work might productively explore ways to form diverse teams and overcome these challenges in a limited group of participants.

In addition, our "character sheet" model for team member skill ranking is exploratory, and provides minimal guidance to participants on what scale to use to rank their own skills or what to expect from others. Future work might develop, refine, and validate this model for skill identification and options for more objective skill assessments and standardized rating scales to further facilitate team building.

Finally, while our workshop did show some change in adult perceptions of STEM identity, future work should further develop multigenerational workshops that more explicitly invite parents/caregivers to actively develop assistive robotics projects with their children.

6 Conclusions

Our playful engineering workshop invited Girl Scouts ages 5-18 to design and build their own assistive robots to address access needs they or their teammates experience in their everyday life. Our workshop was successful at engaging girls in assistive robotics and building robotics knowledge, building understanding and awareness of accessibility and a broad definition of assistive technology, and in building STEM interest and identity. We additionally found that workshops where adult caregivers learn alongside their children can be somewhat effective in promoting adult learning. More research is needed on how to engage multigenerational groups in active learning together, and on the long-term effects of engagement with assistive robotics at an early age for building STEM identity and the pursuit of STEM careers.

7 Acknowledgements

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A Study Instruments

A.1 Pre-Workshop Survey

- How much do you know about robotics?
  - None at all (1)
  - A little (2)
  - A moderate amount (3)
  - A lot (4)
  - A great deal (5)
- How much do you know about accessibility or assistive technology?
  - None at all (1)
  - A little (2)
  - A moderate amount (3)
  - A lot (4)
  - A great deal (5)
- Do you think of yourself as an engineer / "STEM person"
  - Definitely not (1)
  - Probably not (2)
  - Might or might not (3)
  - Probably yes (4)
  - Definitely yes (5)
- If so, why? If not, why not?

A.2 Post-Workshop Survey

(Excludes assent and identification questions)

- How much did you know about robotics before this workshop?
  - None at all (1)
  - A little (2)
  - A moderate amount (3)
  - A lot (4)
  - A great deal (5)

- How much do you know about robotics now?
  - None at all (1)
  - A little (2)
  - A moderate amount (3)
  - A lot (4)
  - A great deal (5)
- What would you like to tell us about what you learned about robotics?
- How much did you know about accessibility or assistive technology before this workshop?
  - None at all (1)
  - A little (2)
  - A moderate amount (3)
  - A lot (4)
  - A great deal (5)
- How much do you know about accessibility or assistive technology now?
  - None at all (1)
  - A little (2)
  - A moderate amount (3)
  - A lot (4)
  - A great deal (5)
- What would you like to tell us about what you learned about accessibility or assistive technology?
- Do you think of yourself as an engineer / "STEM person"
  - Definitely not (1)
  - Probably not (2)
  - Might or might not (3)
  - Probably yes (4)
  - Definitely yes (5)
- Would you like to learn more about robotics, engineering, assistive technology, or accessibility?
  - Definitely not (1)
  - Probably not (2)

  - Might or might not (3)
  - Probably yes (4)
  - Definitely yes (5)
- What do you wish you had learned more about today, or could learn more about in the future?
- Did you enjoy this workshop?
  - Not really (1)
  - A little (2)
  - A medium amount (3)
  - A lot (4)
  - It was amazing! (5)
- Would you like to come to another robotics workshop at Tufts?
  - Yes (1)
  - Maybe (2)
  - No (3)
- What did you like most?
- What did you like least?
- Is there anything else you'd like to tell us?

A.3 Observation Worksheet

- Section: opening and group activities
  Observation: What are the Girl Scouts doing? What are the adult chaperones doing?
  Do they look engaged, bored, distracted (on phones, etc)?
- Section: Brainstorming and team forming 10:30-11
  Observation: What kinds of teams are they forming? Are they sticking to the people they know or reaching out to others with similar interests?
  What questions do they have for the LAs?
- Section: Plan your robot and start building 11:00-12:00
  Observation: What are the Girl Scouts doing? What are the adult chaperones doing? What questions are they asking the LAs?
- Section: Following a program game 12:30-1
  Observation: How are the Girl Scouts reacting to the game? Do they seem engaged? Is it fun, confusing, etc? Do they have questions?

- Section: Design, build, and program a prototype 1-2
  Each team presents their robot to one other team for feedback 2-2:30
  Design modification and improvement 2:30-3:15
  Observation: How are the teams interacting with each other? How are they interacting with the LAs? Within the teams? Are they making good progress or having trouble? Is there anything in common between the teams doing well vs the ones having problems? What questions are they asking the LAs?

- Section: Plan your design presentation 3:15-3:30
  Section: Present to the group (20 groups, 2 minutes each plus transitions) 3:30-4:30
  Observation: What do the Girl Scouts think is important about their robot to present to the other teams? How do they seem to feel about presenting?

- Section: Closing and awards 4:15-5
  Observation: How are the Girl Scouts engaging with the awards? How are the chaperones engaged?

- Post-session:
  What do you hear or see Girl Scouts talking about as they are leaving? What are chaperones doing or saying? How do they look (happy? Excited? disappointed?) What questions are they asking?

B Workshop Coverage of Girl Scout Badge Requirements

For GSUSA badges, including the robotics badge series, the Girl Scout has to complete 5 requirements (3 for Daisy-level badges) with either one of the suggested activities in the badge packet materials or an equivalent activity. For the purposes of our workshop, we focused on covering the requirements for one badge for each level for girls Brownie age and above (grades 2-12), and cover the requirements for all three badges at the Daisy (Kindergarten/1st Grade) level. However, due to the multi-age environment and our additional focus on robotics and accessibility, we also cover some requirements from the other Robotics series badges, which we noted for and provided to Girl Scout participants and troop leaders who might wish to complete those badges on their own or with their troop. Table 5 breaks down the coverage of badge requirements by workshop activities.

Table 5: GSUSA Robotics Badges: Coverage by Workshop Activities

Level & Badge Name	Badge Requirements		
	Fully Covered	Partial	Not Covered
Daisy			
What Robots Do	3	0	0
How Robots Move	3	0	0
Design A Robot	3	0	0
Brownie			
Programming Robots	1	3	1
Designing Robots	5	0	0
Showcasing Robots	3	0	2
Junior			
Programming Robots	2	3	0
Designing Robots	5	0	0
Showcasing Robots	3	0	2
Cadette			
Programming Robots	2	3	0
Designing Robots	5	0	0
Showcasing Robots	3	0	2
Senior			
Programming Robots	1	3	1
Designing Robots	5	0	0
Showcasing Robots	4	1	0