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Promoting Belonging and Breaking Down Gatekeeping in Youth-Centered Engineering Spaces

Kiana Alexa Ramos
Julia Gardow
Emanuel Joseph Louime
Eunice Yujin Kang
Dr. Avneet Hira, Boston College

Dr. Avneet Hira is an Assistant Professor in the Human-Centered Engineering Program and the Department of Teaching, Curriculum and Society (by courtesy) at Boston College.

Promoting belonging and breaking down gatekeeping in youth-centered engineering spaces

Abstract

In recent years there has been a movement to increase accessibility to technology-rich environments like makerspaces for traditionally underserved youth in engineering. Several pro-Makerspace actors purport that having experiences in such open-ended project-based settings can encourage engagement with engineering. However, as we know from prior work in the area, simply providing access to technology-rich spaces does not allow underserved youth to feel ownership and belonging in both makerspaces and engineering environments. Additionally, formal and informal engineering education experiences do not center on preventing harm to communities and the environment in engineering work. Not only do future generations of engineers need to reduce the harm caused by engineering and technology proactively, but harm reduction also offers authentic real-world applications to engineering problems that may create a more human-centered approach to addressing problems within communities.

Background and Rationale

Research Context

Makerspaces are often looked at as panaceas for inclusion, but in practice are often not [1], [2]. Makerspaces have the goal of encouraging underserved youth to express their creativity and learn through a hands-on technology-rich environment [3],[4]. However, there has been little evidence that these makerspaces provide underserved youth with a sense of ownership and belonging. Additionally, the engineering field has historically lacked the acknowledgment that some engineered projects and designs are harmful to society and have traditionally negatively impacted underserved communities.

To this end, we propose integrating youth as leaders in technology-rich environments to encourage feelings of belonging in engineering and promote harm reduction in the field. The role of youth leaders in the program is to collaborate with our lab project team leaders (who are undergraduate students) in creating and facilitating the program curriculum. In sharing ownership of the project, we hope to further the sense of belonging and solve community-based issues. This program is currently being implemented in a ten-week workshop within an afterschool program assisting youth from resettled families with refugee and migrant experience in the United States Northeast. The workshop is structured into 10 total meetings, with sections broken down into: introduction to engineering tools, introduction to harm reduction in engineering, convergence and divergence in prototyping, and ending with a celebration of the final designs. The overall study aims to explore how the implementation of youth leadership in technology-rich spaces may: 1) support youth in leading explorations of how technology use and creation can support a sense of belonging in engineering; 2) further develop a framework to center preventing harm to people and the environment along with youth; 3) explore the role that intergenerational relationships can play in informal student learning.

Background Literature

In a study of 21,444 9th graders, Mau and Li [5] found that students exhibiting higher math/science self-efficacy and identity were more likely to pursue careers in science, technology, engineering, and math (STEM). Further there is a technological divide in underrepresented communities driven by financial factors, school structures, traditional pedagogical practices, and peer dynamics informed by gender, race, and socioeconomic factors [6], [7], [8]. Master and Meltzoff [9] propose the STEMO (STEreotypes, Motivation, and Outcomes) to understand cultural stereotypes and foster a sense of belonging in STEM to counteract gender gaps. They recommend interventions to broaden stereotypes, strengthen belonging, and foster a growth mindset to counteract preexisting dynamics contributing to a lack of belonging among youth. Our project's focus on strengthening belonging through the use of youth participatory action research (YPAR) in technology-rich spaces to develop deliverables iteratively, cater to these recommendations.

As shown technology and makerspaces provide opportunities to create physical artifacts that build personal connections with engineering and technology [10], [11], [12], [13]. However there have been unequitable uses of said spaces and resources for youth from underserved communities that place youth at a disadvantage compared to their more privileged peers [1], [14], [15], [16]. Therefore the use of YPAR in technology rich spaces, youth may use research methods to make sense of and address social problems impacting their communities [17]. Adopting YPAR practices provides an opportunity for positive youth development Anyon et al. [18], developing meaningful adult-youth partnerships and uncovering empirical findings to inform the operations of the informal learning setting. Thus, the use of YPAR methods in addition to the benefits of technology may be used to strengthen youths' sense of belonging in engineering. Our project's focus on strengthening belonging through YPAR in technology-rich spaces to develop deliverables iteratively, caters to these recommendations. In this paper we report on our experiences of developing a partnership with a youth organization and initial work to understand their conceptions of engineering and invite youth to take on leadership roles.

Approach

We are broadly interested in the following research questions and for this paper, we focus on RQ1 and 3.

RQ1: How and in what ways can youth experience belonging in engineering when working in technology-rich spaces?
RQ2: How and in what ways can youth be motivated to prevent harm to people and the environment when engaging in technology-rich engineering activities?
RQ3: How do youth lead the development and maintenance of a technology-rich engineering space?
RQ4: What role do intergenerational relationships play in student learning in informal technology-rich settings?

These questions are the basis for our research study as we collaborate with the Safari Youth Club in a on-going 10-week program. The Safari Youth Club is a nonprofit organization

that supports refugee and immigrant youth as well as their families. Youth served by the Safari Youth Club are aged between 1 year to over 16 years old. The organization provides arts and sports opportunities, and academic support for these youth. One of the several programs the organization offers is an afterschool program from 4pm to 7:30pm. This program aids youth with homework, and provides youth with mentoring, sports activities, and hygiene education to name a few. As a part of our research, we were able to collaborate with 17 youth whose ages ranged from 8 to 16 years old. The youth and/or their families have refugee or immigrant experience from the countries of Democratic Republic of the Congo, Somalia, and Burundi. Our data sources include first-person narratives from the youth, equity conjecture maps, and artifacts created during the program.

To answer our research questions, below we share the educational programming (including how it was planned and how it was eventually implemented), observations, artifacts, and researcher notes to share experiences of program implementation and takeaways for future iterations. As to date there have been a total of four on site visits to the Safari Youth Club, data will be continuously collected to answer all aspects of our proposed research questions. As of now, results from the sessions best support answers to RQ1 and RQ3. This paper and the researcher observations/notes below are led by undergraduate student researchers who are mentored by the PI on the study, but the student researchers lead all research efforts including study design, program development, data collection and analysis.

Outline of Proposed Educational Programming

The proposed program is broken down into two-hour meetings week over a total of 10 weeks. Program design is intended to support youth from 8 to over 18 years old. The 10-week program is divided down into a total of three learning periods: introduction to engineering tools, introduction to harm reduction in engineering, convergence and divergence in prototyping, and ending with a celebration of the final designs. Although each period may appear to be distinct, each period builds upon the next allowing youth to complete a project meaningful to them.

After the first learning period research team members will work in collaboration with Safari Youth Club facilitators to elect youth leaders from the group of active youth participants. In this election process we are looking for youth who are actively engaged in all programming and demonstrate a desire to learn new engineering skills. The role of youth leaders is to collaborate with the research team members in the creation and facilitation of curriculum and programming specific to the site. During workshops youth leaders are expected to assist their peers in completing tasks and projects as well as maintaining a positive, welcoming learning environment for all. In the role of a youth leader, we are sharing ownership of the project in order to create better programming tailored to the youth group being served. As these youth move on, the hope is that a new cohort of youth leaders would take their place.

In order to develop a sustained technology-rich environment we envision providing youth with equipment to be left at the program headquarters. This presence of the equipment along with the training of equipment would allow for youth to have extended access to the technology beyond just the scope of the program workshop days. Thus youth leaders would further be able

to hold leadership positions within the technology-rich environment because of the skills that they will be able to share.

Implemented Educational Programming

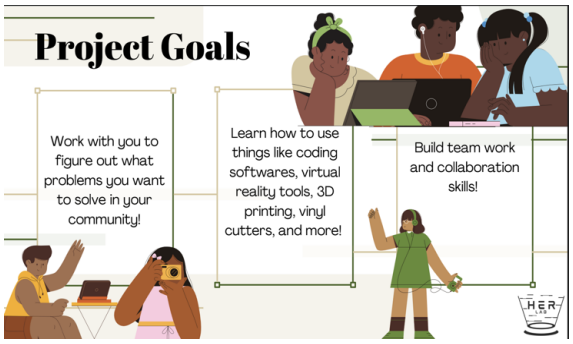


Figure 1. Slide two of PowerPoint presentation of program introduction slides for Safari Afterschool Program listing project goals with figures of youth working with technology.

Figure 2. Slide three of PowerPoint presentation of program introduction slides for Safari Afterschool Program filled with images of youth working with technology and different design

As stated, the program is designed for a total of 10, two-hour workshops, with each visit happening on a weekly or biweekly basis dependent on availability of both researchers and Safari Youth Club. To date there have been four visits on site, with the first visit being used to collect consent and assent for prospective participants and three weeks of activities. Workshops are ongoing but this paper only uses data from the visits completed prior to the start of writing. Additionally, the Safari Youth Club serves youth between the ages of 1 to over 16 years old but, our programming serves those 8 years of age and older.

In order to begin data collection and working on site with the youth, we first needed to collect assent and consent. Consent and Assent was collected in line with an IRB protocol approved by the University partner's IRB office.

For week zero, we prepared a PowerPoint introduction of the project to share with youth as shown in Figure 1 and 2, as well as two simple activities using the Oculus VR Headset and introduction to 3D printing with TinkerCAD, to generate excitement about the upcoming program. Youth were broken up into two groups each getting to try working on each activity while youth were pulled individually to gain assent. Our main goal was to gain verbal assent and engage interest as much as possible. Initially we were to arrive onsite at 4:30, approximately an hour into the Safari Program had begun due to limitations on research team members availability. Upon arrival at the Safari Youth Club site at the elementary school, youth were all around in a gymnasium playing with basketballs and soccer balls. Safari Youth Club leaders helped identify youth who fit the age range for our study. Youth were initially pulled individually and read the script for verbal assent before collecting names. However, we ended up pivoting to reading the script to small groups of youth (2-3) at one time and then collecting assent from youth, which is in line with the approved IRB protocol. In final we were able to create a group of 17 participants aged 8 to 16 years old.

We began week 1 by bringing in a 3D printer to leave on site and run prints while working a sticky note ideation board with the youth. On several poster boards we wrote prompts pertaining to identifying problems within their community, belonging in informal and formal learning environments, as well as codesigning the program with the youth. The first question was, “What is your favorite food?”, research team members began by demonstrating the process with the first question and youth were asked to then do the same. Youth were given stacks of sticky notes and were encouraged to answer questions individually and were still allowed to communicate amongst each other and with research team members. Some poster boards contained multiple questions that aimed to build upon each other. Youth were instructed to answer each question on the boards. Poster boards with the question sets were displayed as follows;

1. What is your favorite food?
2. What does the word engineering make you think of? What technologies do you use every day?
3. What type of problems do you want to solve? What would you need to solve these problems? How can we help you solve these problems?
4. What place or activity makes you happy? What do you like about this place or activity? What do you like most about school? What would make school most enjoyable?
5. What activities or places have made you feel heard or included? What could we do to keep you working with us? What could we do to make sure everyone feels included here?
6. Who do you think is an engineer? What kind of engineering activities have you participated in?
7. Have you built things with your hands? What is a project you made that you are most proud of?

Week two on site was used to formally introduce the youth to TinkerCad and further investigate the youth's perception of engineering. We brought with us a worksheet to allow youth to answer the question, “What does engineering look like in your community?”. The worksheet provided a large blank space where youth may illustrate the problem along with a few lines to describe their illustration. We also designed a simple name tag activity that would teach the youth about basic CAD tools like, using premade shapes, extrusions and creating holes, as well as working with different viewpoints and dimensions throughout the work space. Youth were asked to design a small nametag and were constrained to using a rectangular base and could not require any supports to print, we brought examples of the name tags for the youth as seen in Figure 3. Youth were able to use TinkerCad on both chromebooks and Ipads that were provided by the research team. The group were split in half to ensure less issues with internet connectivity, where one group worked on the name tag activity while the other world on answering the engineering question.

Figure 3. Sample of nametags of research team members used to provide examples for youth.

Week three consisted of a set of reflection questions intended to help youth identify problems they may want to solve by the end of the project workshop. We did this using another set of poster boards ideation prompts. The first board prompted youth to walk through their daily routine and categorize into six different time periods: waking up, morning, noon, late afternoon, night, and bedtime. Youth were encouraged to add in any parts of their routine for every part of the day. Research team members verbally explained approximate time references for each period and provided examples of activities they would be doing. After this another poster board following the same division of time was brought out and youth were prompted to think of problems they could identify during their daily routine. Youth were ensured that all problems they could think of were valid for this exercise, allowing them to include all levels and sizes of problems in their world even if they seemed miniscule. After all participating youth had completed identifying problems, research team members read through each of the problems with the youth to help identify themes or similarities. Finally on the last poster board youth were prompted to brainstorm potential solutions or suggestions of how to fix these larger problems identified as a group. Youth also received the name tags they had designed during week two.

Findings

Week Zero

Upon arrival, youth were intrigued by all the equipment we had with us and wanted to know more about what we were doing at the Safari Youth Club. We began setting up in the gymnasium because there seemed to be no other space for us to begin programming. This became an issue after separating youth of age of possible participation from those underage because those underage began to play basketball and soccer in the same space. This distraction made it difficult to collect the entire attention of all youth and we were not able to share our PowerPoint all at once. Rather we immediately split the groups into two and began to have them use the VR and TinkerCAD activity. We initially began to pull youth individually to read them the assent script, however this began to be an issue time wise, so we began reading the assent scripts to small groups of two and three. After collecting assent, we spoke with Safari Program facilitators about potentially finding a new space, they showed the old cafeteria in the back of the gym, that was being used as a closet space. However, it had doors that would allow us to work with youth while removing distractions so we planned to use that space the following week.

Week One

As mentioned previously, for Week 1 we began research activities. We aimed on getting to know the youth and understanding their perspective on engineering and technology. We set up poster boards with various questions and allowed the youth to add their responses through sticky notes. Sticky notes allowed all the youth to respond without any anxiety related to participation. In completing this activity researchers noticed that a majority of youth had a tendency to look for a “correct answer” within each other and out of researchers. Additionally, youth often struggled with identifying or fully expressing problems within their personal lives, outside of issues in

school. All of which is further documented and discussed by the researchers in the final thematic analysis.

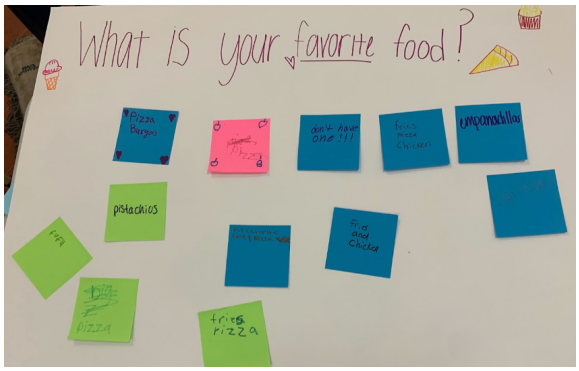


Figure 4. Q1 with youth answers

Q1: What is your favorite food?

The youth were definitely a bit hesitant at first but began to enjoy the process itself as they began to discuss among their peers. Many of the youth had questions about spelling which set the precedent of being able to ask us questions and generally build trust. Some youths were very comfortable vocalizing their answers while others were more timid, keeping their answers on their sticky notes. We would often vocalize the answers of youth who were shy, to affirm and value their voice. This helped the more timid youth build confidence.

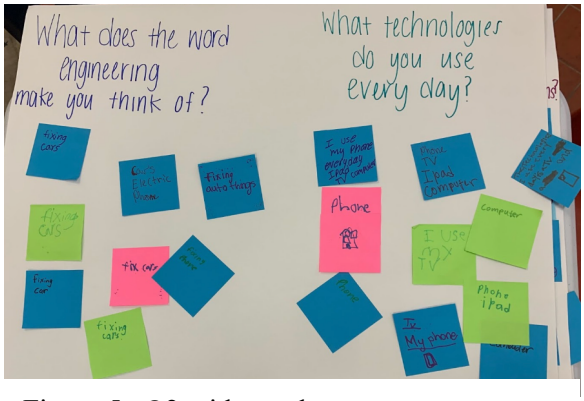


Figure 5. Q2 with youth answers

Q2: What does the word engineering make you think of? What technologies do you use every day?

The youth hesitated a lot more when it came to answering the first question, as this probably felt like more of a "right/wrong" answer situation. As program leaders, we encouraged that every answer was valid. Once one student vocalized their opinion, more and more youth began to participate and feel more comfortable. While youth were writing their answers, we continued to aid them with spelling. The answers to these questions were technologies like televisions, phones, and cars, all things that youth do not know how to build themselves. This suggests that their knowledge of technology and engineering are based upon complex, expensive inventions rather than something as simple as a water bottle or toothbrush.

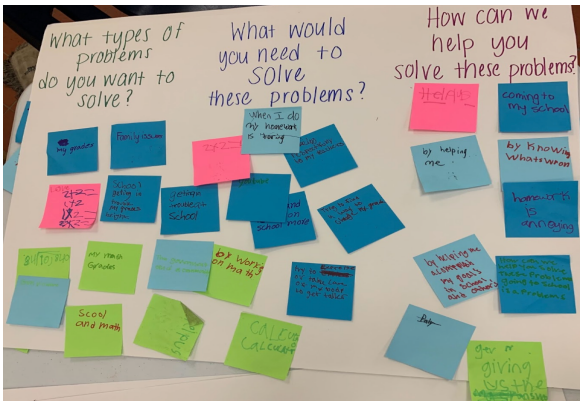


Figure 6. Q3 with youth answers

Q3: What types of problems do you want to solve? What would you need to solve these problems? How can we help you solve these problems?

The youth became more comfortable with the activity and thus we saw a broader range of answers. Power dynamics within youth showed more as they began to tease other youth about their answers, specifically the listed multiplication table. Youth were independent in answering the middle question aside from asking for spelling help. The question, "How can [the research group] help you solve these problems?" was more challenging for youth to think of, especially because they still do not know us very well. A lot of reassurance was required from us project leaders as youth were confused and hesitant to answer these questions. The number of questions on the board seemed a bit overwhelming. Not all youth were able to answer each question, but rather answered the ones they felt most comfortable with. The answers between the three did not vary too much.

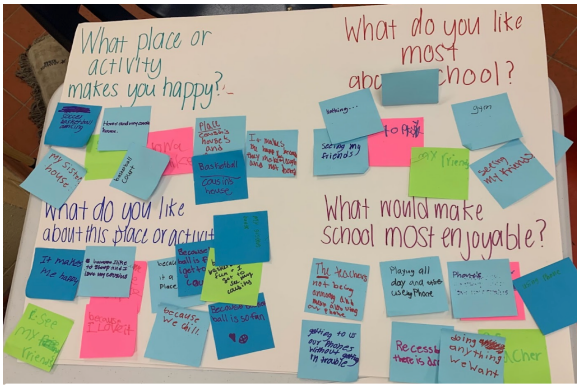


Figure 7. Q4 with youth answers

Q4: What place of activity makes you happy? What do you like about this place or activity? What do you like most about school? What would make school most enjoyable?

The youth had a harder time describing what exactly made them happy about the place or activity. A lot of verbal responses were just: "it's fun!" which may just stem from not really knowing how to express themselves fully. We managed to help guide them through each question one by one as there were a lot of questions on this board. We also gave our own answers to these questions as encouragement for the youth to think of their answers. Some youth who were really into the process wanted to zoom through each question while others started to become more disengaged. This led to youth moving at different paces.

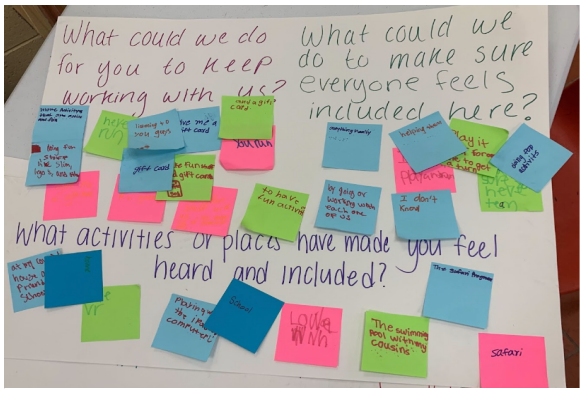


Figure 8. Q5 with youth answers

Q5: What could we do for you to keep working with us? What could we do to make sure everyone feels included here? What activities or places have made you feel heard and included?

For the inclusion question most youth answered with the Safari Program. We were in the space where they felt most heard and included which is important to note as they may not have been engaged in our activities if we had met them in a different setting. The pink one that says "Lownh" is supposed to be Iowa. The student had mentioned this is where her favorite cousins lived: she claimed that she wasn't able to see them often but was excited because they were coming to visit her family for the holidays. There were a variety of answers among the youth. They posted how they feel valued around friends which are a big part of feeling a sense of belonging in the first place. There was less hesitation in answering this question.

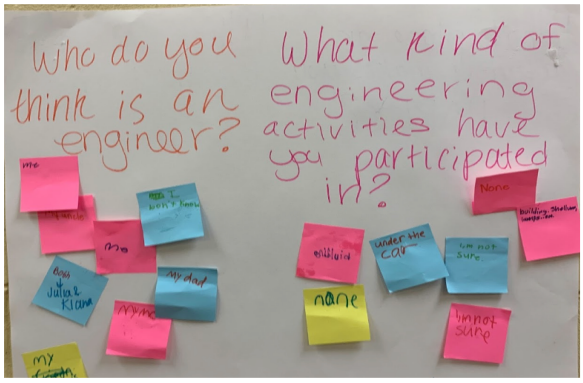


Figure 9. Q6 with youth answers

Q6: Who do you think is an engineer? What kind of engineering activities have you participated in?

For the question of "Who do you think is an engineer?", a lot of youth mentioned family because they have positions as mechanics. A youth said that our program leaders were engineers. These leaders had introduced themselves as engineering youth. Other youths expressed that they were engineers or someone else was engineer because they could put together shelves or things that their families had bought. This activity seemed to have allowed them to acknowledge how simple engineering can be, and that it is all around us.

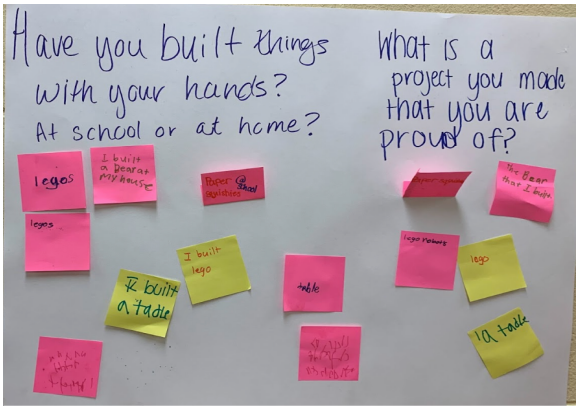


Figure 10. Q7 with youth answers

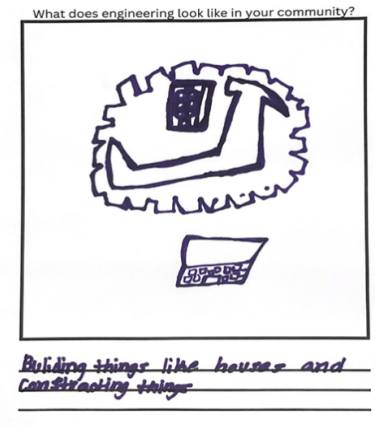
Q7: Have you built things with your hands? At school or at home? What is a project you made that you are proud of?

Most of the youth mentioned the same projects for both questions. The little squiggles are from younger youth who are interested in the process, we can then see how the little ones are also intrigued in learning about who we are and what we're doing. By this point our program leaders did not have to give the youth much encouragement, as they had become very comfortable with this process.

Week Two

In Week Two we engaged the youth in a 3D printing activity and a drawing activity. We split the group into two smaller groups. One would do the drawing activity, answering the question, 'What does engineering look like in your community?', while the other would use chromebooks and iPads to create a keychain with their name on it. The majority of the youth wanted to do the 3D printing activity as they were intrigued by the iPads and chromebooks. With the use of technology came many technological issues such as connecting to the internet or to the 3D design software, Tinkercad.

When posed with the question, "What does engineering look like in your community?", youth were at first confused on how to potentially answer. Some turned to the internet in hopes of finding a specific answer, which resulted in a lot of pictures of gears or construction sites as shown in Figures 11,12, and 13. Research team members began to actively step in to direct youth from using ideas completely from the internet by recentering the question around their community. Some youths were very insistent that the pictures they found on the internet accurately represented their community. However, others were able to vocalize other instances of engineering more directly reflecting their experience as shown in Figures 14, 15, and 16.



"Figure 11: Description, illustration of gears and other electronics, "Building things like houses and constructing things".

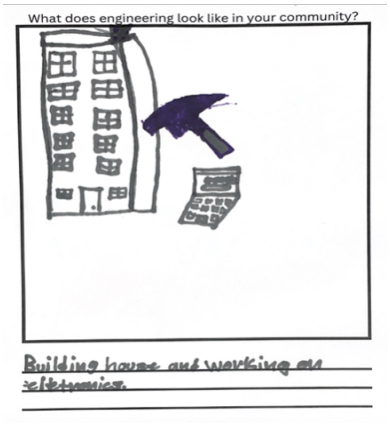


Figure 12: Description, Illustration of building, hammer, and an electronic device, "Building house and working on electronics".

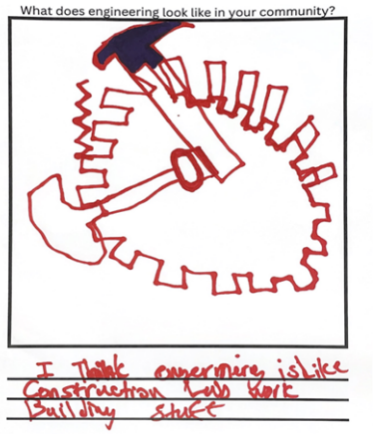


Figure 13: Description, illustration of gears and hand tools, "I think engineering is like construction lab work

Figure 14: Description, illustrates a car being fixed, "Where I live we fix cars and clean and sometimes we have to take off the tire".

Figure 15: Description, illustrates a camping tent with child inside another child outside camping tent, "Me and sister camping".

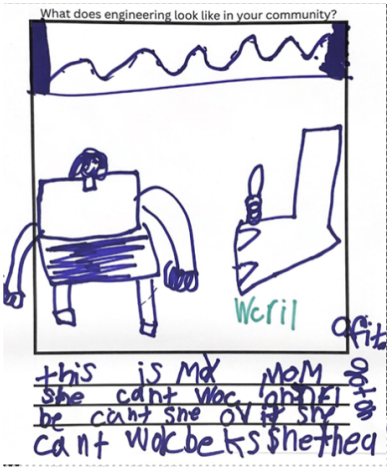


Figure 16: Description, a woman next to a wheelchair, "This is my mom, she can't walk...(illegible)".

For the CAD activity, we began by teaching the youth how to make a box shape as the base of their keychain, a few youths got it while others became frustrated. With limited program leaders working amongst a larger group of youth, which made it difficult for each youth to get the immediate help they needed, as demonstrated in Figure 17. When helping the youth one-on-one they became really excited about how creative they could be. Their eyes lit up when they saw the little figurines like basketballs and hearts that they could add to their 3D design. Many of the youth struggled with adjusting the dimensions of their keychain but were able to locate and ideate everything they wanted on their keychain. Many were fascinated by the scribble tool on

Tinkercad where they were able to draw their name into their 3D design. This power over their name and design was really encouraging to them. One particular youth made a keychain for his mother, it had ‘Best Mom’ engraved on it. A few other youths made keychains for their siblings and friends revealing the strong sense of unity and love within the community.

Figure 17: Research team members assisting youth in the creation of designs.

Week Three

This activity was planned specifically in response to youth struggling to identify problems outside of a typical mathematical environment. We hoped further breaking down the youth’s days would allow for them to further recognizes grievances within their daily routines. Youth began the first walk through of their life largely confused by why we were asking them to a day in their lives. Compared to our first poster board activity, youth were a lot more confident about adding answers to the board. This may also come from the prompts of this week were framed to avoid questions that appeared to have a single answer, therefore less time had to be spent on determining what youth believe a right or wrong answer to the prompt. However this ease of participation slowed as we began asking youth about potential problems in their everyday lives. Youth required a lot more assistance from us in brainstorming problems. Prior to beginning the activity we believed that this would be the case because when we previously asked youth to identify problems they would like to solve, answers seemed based on mathematical problems they would solve in school. Thus, identifying problems in their lives stumped many youth, we encouraged them to recognize even the smallest of annoyances in their daily routines to help validate their problems. We also encouraged youth to look back at the first poster board to base any issues around the parts of their routine they highlighted.

Finally we reviewed the problems they listed as a group and they enjoyed relating to the issues that others identified. This was particularly interesting between youth who were related in some way (siblings, step-siblings, or cousins) as they often mentioned each other in their problems. These family related problems are often related to another youth taking too long to get ready in the mornings or not listening to their parents or guardians. We encouraged these conversations to help facilitate similar themes between the youth. Older participants required less

assistance in identifying problems in their lives as compared to younger participants. We assume that this may be due to growing responsibilities with age or better understanding of the world around them that comes with maturity. However once we began trying to identify solutions to common problems, we found that younger participants needed less support in brainstorming problems than older participants. Once again, we may assume this because of the nature of maturity as older youth have become more accustomed to their circumstances not having changed over a large period of time. For the majority of youth, we had to encourage them that their solutions did not need to completely solve the problem rather they may offer ways to better the issues. This allowed for more youth to feel more confident in presenting their answers.

Thematic Analysis & Discussion

RQ1: How and in what ways can youth experience belonging in engineering when working in technology-rich spaces?
RQ3: How do youth lead the development and maintenance of a technology-rich engineering space?

As we reflect on the past sessions, we found some key themes around belonging in engineering learning environments and the maintenance of technology-rich spaces. These themes primarily reflect answers to RQ1 and RQ3, as we continue on with the workshops, we hope to further expand information surrounding our other research questions. We found that a majority of youth have trouble identifying problems within their communities. Problems that the youth most often identify with align with problems typically addressed in formal learning environments like mathematics. Additionally, a majority of youth often struggle with tendencies to search for what they believe is the "right" answer. These tendencies were displayed in a variety amounts from uncertainty in expressing answers to using the technology available to them to look for the answers. Finally, working with youth of a wide age range we have found that the natural leaders in our group are often the older siblings and cousins. These youth most often set the tone of the general excitement towards the project. These themes were reflected each week by a majority of the youth and helped us form the basis of all of their past and future program curriculum.

Math and school are our real problems: Challenges with identifying Authentic Engineering Problems

Issues with problem identification arose early week one with our poster board activity. The questions centered around problem solving, "What types of problems do you want to solve? What would you need to solve these problems? How can we help you solve these problems?" made it very apparent that youth had trouble identifying problems outside of a formal learning context. Many of the youth began to list specifically mathematical problems or brought up concerns surrounding their grades. For youth listing these mathematical questions we assume that they associate the word, "problem" in the mathematical context they see in school. This was a trend especially prominent with our younger youth, aged 8 to 10 years old. We assume that this correlation of the word "problem" is what created their answers to be based on mathematical concepts. However, we don't believe that these are necessarily the problems the youth want to solve; rather, having these answers placed (as sticky notes) reflects the theme of youth searching for what they believe is the correct answer. Hence, with relating mathematics to problems, they

saw these mathematical problems as the correct answer to our question, which is a theme that carried heavy weight in a lot of these activities. Outside of the mathematical context, a majority of their answers to what problems they would like to solve at school were regarding both grades and their own behavior. Initially we saw these answers more in correlation to the actual mathematical concepts however, after more reflection we believe that they may reflect general anxieties about formal learning environments.

After noticing these issues in week one we decided to create the "Day in the Life" activities in week three to help youth look beyond the context of school to address problems. We hoped that breaking down the day into smaller sections would allow youth to think about their daily routines both in and out of school. Which we believed would allow them to think of problems in their community. Attending school is the largest part of the day for youth in these age groups so we understood that potential identified problems would still include school related issues, but hopefully broaden their scope outside of mathematics. Yet again when prompted to think of problems or grievances in their days, there still came with a lot of hesitation from youth. Expecting this, research team members attempted to work with youth in small groups and individually refer to their daily routine to think of problems in their lives. For about half of the youth this seemed to help motivate them to identify problems. However, for youth who were still struggling, research team members began to provide examples of their routines at same time periods to identify problems there. After sharing these examples, research team members were careful to encourage these youth to think of the examples considering their own routines to help steer away from youth waiting on what they believed was a correct answer from research team members. In doing this youth were able to generate more problems outside of the scope of mathematics and formal learning environments which proved to be successful in identifying problems.

Going forward we plan to assist youth in the identification of problems by resharing our initial project goals. Week zero was successful in collecting assent for the project however we don't believe that it was extremely beneficial to helping youth understand what our project goals were for them. As we began week zero without a designated space for us to meet, we began in the gymnasium holding all of the youth at the Safari Youth Club. Being in the gymnasium created a lot of distractions as non-participating youth played basketball or soccer in the space. Thus, we weren't able to show our PowerPoint to the participating youth as a group. Next time on site we hope to begin by showing this PowerPoint and overall reinstating that our goal for them is to use engineering skills to potentially come up with a solution for problems within their community. This in turn may help them in problem identification because they will have a sense of direction as to why problem identification is so crucial to our project.

Tell me what the right answer is: The problem with correctness

The youth's desire to find the "correct" answer to our question is prevalent in most of the activities we have conducted with them. Previously we mentioned the correlation of the word "problem" to its mathematical context, but even these are within the theme of youth looking for the "correct" answer. We define this "correct" answer as responses to our questions where youth avoid responding with their initial thoughts relevant to their life in place of what they believe we are looking for from them. We assume that this is related to traditional learning environments in

which questions in class or on exams have one correct answer to them. For our purposes, this mindset is detrimental to having youth share their own beliefs and create projects meaningful to them. As highlighted in week two with our, “What does engineering look like in your community?” worksheet when youth look for the “correct” answer we lose all potential to understand their beliefs about the topic. We described that youth searched the internet for images of engineering, answers to this search are filled with many images of construction sites or plans, stock images of people in hard hats, and drawings of gears and hand tools. All of which is fine for youth to draw inspiration from however it may invalidate any of the potential ideas youth had initially and completely ignores the key part of the question asking about engineering in their community. This desire of searching for the correct answers was ultimately counterproductive for youth as they reshared what they found online in the worksheets we received back. Where some youth described their personal experiences, like family members being mechanics, building tents while camping, or the use of electronic wheelchairs at home, the majority of youth mimicked what they had seen online.

Despite encouragement from research team members to think more specifically about their own experiences during the worksheet activity or encouragement to include all of their relevant thoughts during poster board activities; the desire to search for “correct” answers hurts the individuality of youth in the expression of their thoughts and ideas. In such short time periods, there is only so much research team members can do to encourage youth to be confident in their unique ideas and answers. In creating a technology-rich environment for the youth, part of creating belonging requires youth to be creative while exploring their own ideas and paths. However, as in traditional learning environments where “correct” mannerisms, ideas, and answers are highly valued, youth may have trouble working out of this mindset. This is not to say that traditional problems with “correct” or “incorrect” answers aren’t necessary for learning but rather points to gaps it may create in belonging for youth. When youth were completing the TinkerCad name tag activity we encouraged them to design and learn independently to come up with a unique design of their own. At this point youth were fully engaged in learning, helping each other discover new skills, and felt confident when asking research team members for additional instruction; youth were empowered by their ability to learn new skills without fear of needing to fit into strict constraints of “correct” or “incorrect”.

To continue to assist youth feeling empowered in our learning space we plan to add in more activities that will allow for independent learning in addition to completing similar worksheet activities in smaller groups. The TinkerCad name tag activity was so successful because it gave youth direction while providing them the opportunity to explore on their own. It allowed for youth to discover new skills individually and then they were able to share that with their peers. Having more activities like this will allow for the introduction of new technical skills and more peer-to-peer learning, boosting confidence for all the youth participating. Further we plan on revisiting similar activities in a smaller setting working with groups of two to three youths to ask them questions about engineering or problem solving. This may alleviate pressure of youth needing to find the “correct” answer by removing pressure from the large group. Additionally, working with youth more individually will strengthen the relationships between youth and research lab members, allowing for youth to create a better sense of confidence when answering questions and developing feelings of belonging. We understand that anxieties about

traditional learning environments will continue to persist but hope to continue to provide a space where youth will feel empowered.

If my older sister does it, then I'll do it: Strong sibling bonds

Working at the Safari Youth Club has provided a unique insight to the relationship between the older and younger youth and the success of creating a sustained space in the future. The Safari Youth Club serves youth of all ages, from young toddlers to youth over the age of sixteen. Even more interestingly is that most of the older youth in the program have younger siblings or cousins that are also in the program. In our participating research group older youth play a crucial role in engagement in activities in both overall excitement and supervision of all youth. For example, during our first session using poster boards, older youth were engaged and were actively participating in adding ideas. However the next time we did an activity with the poster boards in week three, older youth were less excited about actively participating. Thus, younger youth who originally were excited to participate again were more hesitant to. Therefore, it is important for us to continue to engage with our older participants to help focus the entire group. Furthermore, upon arrival there have been a couple of older youth who help gather all of our participants, keep them focused on activities, and essentially work as a behavior management team. Younger youth are often more responsive to these older youth than research team members to refocus their attention. Thus, we can see that these older youth are crucial to completing activities and keeping engaged.

These older youth exemplify the important role of youth leaders that we outlined in our original program planning. In moving forward, we plan to give approximately three youth the formal title of youth leader because of the role that they have played in previous sessions. These youth leaders have been elected after consideration from both the research team and Safari Youth Club facilitators. A majority of these youth are the older siblings and cousins of others in the Safari Youth Club. For our purposes this is beneficial because of the natural respect younger youth have for them, thus allowing the youth leaders to share their skills and excitement with younger generations. Even looking past youth in this participating cohort, younger youth will be able to work with leaders they know and feel comfortable with in the technology-rich space. Formally, these youth leaders in place will further affirm their sense of belonging in the space with the hope that they will maintain the space and continue to participate in the technology even after the program is over. This also provides hope that they will be able to share their skills with younger siblings who then one day will also become leaders on their own.

Conclusion and Future Work

From obtaining consent, to hands-on and reflective activities, our visits have proven to present useful information on the topic of promoting belonging in tech-rich environments implemented in underserved communities. Early on, youth had trouble identifying problems within their community, as many would connect the word 'problem' with mathematical problems. However, working more with the youth, it became apparent that behind these mathematical problems there is the greater issue of having general anxieties about formal learning environments. We would like to further encourage the youth to feel comfortable in describing their current anxieties like school grades, behavior, anxieties at home or in the environment we

visit them in. Connected to the issue of identifying problems, is that of having the need to find the "correct" answer. The need to say the "right" answer limited their responses to the question of problems they observe in their community. We want to encourage the youth that our presence does not indicate any sort of formal learning environment. By this we mean they will not be tested, graded, or deemed invaluable by their answers. Additionally, an outstanding observation from each of our sessions was that the natural leaders of the group were the older siblings. This is essential to our understanding of promoting youth leaders in these environments. Our goal is to give these natural youth leaders a formal title to increase their sense of belonging, as well as those without this title like their siblings and friends.

Our next sessions will be for longer periods where we hope to do more introduction to engineering activities and spend more time individually understanding their feelings of belonging. As stated the program will have 10 total educational workshops, thus in our next 6 workshops we will continue to document data from participating youth in the study. We will perform group STEM activities to empower youth to share their skills with one another. Individually, we will help youth feel more comfortable sharing their ideas without the pressure of saying the "correct" answer or being in a large group by reaffirming them. For future sessions we would like to work in an open classroom to allow youth to be undistracted by gym activities and focused on our engineering activities instead. We also would like to prevent sports balls from tampering with 3D printers, and other fragile technologies. We would be careful to not make this look like an extremely traditional learning environment to relieve any stress/anxiety school might bring. If not, we would like to make the current space we have more welcoming and comfortable by cleaning things up and repositioning furniture. In addition to this we will continue to build upon youth design of the program going forward by modeling YPAR methods. More specifically focusing on youth codesigning the program with research team including decisions about which tools and skills they would like to learn and deciding design approaches. With the upcoming election of youth leaders, we hope to further establish youth ownership over the space for all participants. We also aim to build more on the other research questions as we move forward to better identifying problems and creating potential solutions. For future sessions we plan to introduce harm reduction programming and observe intergenerational learning impacts.

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