ENGINEERING EXPERIENCES FOR MIDDLE SCHOOL GIRLS

An Interactive Qualifying Project Final Report
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Abstract

Worcester Polytechnic Institute's Camp Reach program is looking to upgrade its workshop curriculum and find ways to engage underrepresented minorities in the program. Our project, sponsored by Pre-collegiate Outreach Programs, was to design a multi-day workshop that utilizes WPI makerspace facilities to create a sophisticated engineering experience for 8th grade girls and is designed to promote inclusion. The finished product heavily integrated youth voice to deliver a workshop agenda, recommended makerspace, materials list, learning outcomes and recommendations for inclusivity.

Acknowledgements

This project would not have been successful without the many individuals who guided and supported us. We would like to take some time to recognize and thank them.

First, we would like to thank the middle school girls who participated in our focus group sessions as co-designers for our project. Without their insights, we would not have gotten such an in-depth idea of the interests and needs of middle school girls. All their contributions through each stage of project development were a major reason why our final project is able to be tailored towards middle school girls. We would also like to thank Irene Shaver for helping with developing the focus groups and guiding us in the right direction.

We would also like to thank all of our interviewees. Specifically, we would like to recognize: Suzanne Sontgerath, Shari Weaver, Erica Stults, Geo Interiano, Sarah Jane Woden-Scwartz, Mitra Anand, Adam Sears and James Loiselle. These individuals took time out of their busy schedules to meet with us in order to teach us about topics they had expertise in such as: workshop creation, middle school education, makerspaces, and inclusion to name a few. We thank them for sharing their knowledge and expertise that were essential to creating the foundation of our project and developing the design principles later used to structure it.

Finally, we would like to thank our project advisor, Professor Chrysanthe Demetry from the Mechanical Engineering Department at Worcester Polytechnic Institute, and our sponsor, Suzanne Sontgerath, the Director of the Office of Pre-Collegiate Outreach Programs at Worcester Polytechnic Institute. Professor Demetry and Sontgerath gave us the opportunity to work on this project for Camp Reach. They met with us weekly to guide us, and give us feedback ever since the project started in August 2020. We greatly appreciate all the hours they put in to ensure the success of our project despite the challenges we faced from the pandemic, and our personal development as undergraduate students.

Executive Summary

Background

Women are underrepresented in STEM fields, making up just 28% of the science and engineering workforce (National Science Foundation, 2018). There is also a lack of racial diversity in STEM. In the United States, Hispanics, African Americans, and Native Americans make up 27% of the population age 21 and older but only make up 11% of workers in science and engineering occupations (National Science Foundation, 2018). Diversity is an essential component in STEM fields where a problem may need diverse viewpoints to find the best fit solution. In order to get students, especially women and underrepresented minorities interested and involved in STEM, experts agree that middle school years are important. This is because middle school years are crucial to exposing young girls to STEM because it helps them practice their math and science skills, it broadens their perspectives on STEM, and it helps them promote a holistic approach to STEM which will lead them to choose STEM careers in the future.For this reason, a lot of STEM programs are developed at the middle school level, where girls are most impressionable as they navigate through social norms, peer pressure, and stereotypes.

Camp Reach

Camp Reach, hosted by Worcester Polytechnic Institute (WPI), is a program for middle schoolers that seeks to bridge the gender gap in STEM by teaching girls how to think like engineers and give them the confidence to solve problems. Camp Reach was designed with the intent to help girls realize their self-efficacy in STEM through hands-on workshops and providing them with STEM support by introducing female role models and peers. This teaches girls that engineering majors can provide opportunities for humanistic and people-oriented work. However, diversity and inclusion is an area of improvement for Camp Reach. In the Camp Reach programs,white as Asian girls tend to be the majority of program applicants and out of alumni, they are more likely to pursue STEM degrees in comparison to URM alumni.. Although Camp Reach has made efforts to bridge that gap in diversity through financial assistance and reaching out to community-based organizations, there is still a lot of work to be done to promote diversity and inclusion in the program.

In 2020, the Office of Pre-Collegiate Outreach was interested in making some changes and improvements to Camp Reach. It was decided that Camp Reach's two-week residential timespan is more appropriate for the 8th grade age group. Along with the change in grade, the Office of Pre-Collegiate Outreach would like to consider a new workshop that utilizes WPI facilities. Many of the workshops have not been modernized to reflect the changing environment of the facilities at WPI. WPI has many spaces on campus that include state-of-the-art equipment such as laser cutters, rapid prototype 3D printers, and tools to create and work on projects that can be used to expose girls to new equipment and be able to work on a project from design to prototype.

Goal and Methodology

The goal of our project was to design a multi-day workshop for Camp Reach that utilizes WPI makerspace facilities to create a sophisticated experience for 8th-grade girls and is designed to promote inclusion. The workshop will be a few days long with the use of machinery and will have the girls work together as a team and go through the engineering design process. In the end, they will personalize and present their designs on their own. We accomplished this goal by completing the following three objectives:

1. **Incorporating youth voices.** Youth voice is a mechanism for individuals to express their own feelings realities and by doing so they realize that they themselves are the experts concerning their own experiences and needs. Often, the voices of underrepresented minorities are missing and their authentic lived experiences are misinterpreted. Incorporating voices of young people that have traditionally been underrepresented is essential to better understand the diverse experiences within these groups. We incorporated youth voice through a focus group of middle school girls because they have the ability to provide a different understanding and different insights than college students and professionals. These understandings and insights were necessary for the development of the workshop. Using a database provided by the Office of Pre-collegiate Outreach, we recruited ten female middle schoolers, ranging in age from 12-14. All were from URM groups. By participating in this research with us, our focus group was also collaborating as co-designers for this project..

2. **Identifying best strategies that promote inclusion.** We used our literature review, assembled a focus group to incorporate youth voices, and consulted with professionals. Throughout the process, we wanted to focus on finding practices that promote inclusion and specifically tailor those to URMs. This means that we needed to look into the societal problems that women and URMs face in STEM, then look into methods that WPI and other institutions have incorporated in order to level the playing field and give opportunities for women to succeed. Additionally, we interviewed professionals and held the focus group with middle school girls to understand how we could honor the girl's diverse backgrounds and what steps we could take to help bridge that gap and promote collaboration and racial inclusion in our workshop.

3. **Designing the workshop through phases of ideation, selection, and development.** That was enhanced by interviewing faculty, looking into makerspaces, and working with the focus group. Our first step was having a large pool of ideas that were inspired by the advice and recommendations of faculty and working with the focus group. Specifically, we looked into age appropriateness and our focus group's interest in a real-world application. Next, those were narrowed down through the main criteria we developed from our findings: feasibility within three to four days, compatibility with makerspaces, creative aspect incorporation, real-world problem solving, and age-appropriate curriculum. These criteria narrowed our eleven ideas into four, which were then presented to the focus group to come up with the final workshop idea to expand on. Iterations of that final workshop also benefited from input from the focus group and our sponsor.

Strategies for Inclusion

1. **Middle school girls value project structures that balance teamwork and individual skill development.** Our team quickly realized that middle school girls value project structure and our co-designers suggested for Camp Reach participants to have a balance between working in a team and working individually. Working together in a team facilitates idea generation and creativity and it lets participants practice their listening and communication skills. Most importantly team members with diverse backgrounds will bring diverse solutions to the table, which leads to a more informed decision-making process and increases productivity. Having good team experiences will foster positive STEM relationships.
2. **Multiple learning methods are essential to including and fostering the growth of diverse populations.** One way of helping to improve inclusion is teaching content in multiple ways. This is because students learn in different ways which in turn helps students feel represented. When teaching Computer Aided Design (CAD) in our workshop it is recommended to have at least two different learning methods so that the camp participants feel represented which will help them grasp the concepts of CAD more quickly. This will allow for better growth throughout the workshop.
3. **Including creative elements in the workshop inspires self-confidence and innovation.** Throughout the focus groups, our co-designers made an emphasis on including creative expression in the workshop. Adding those creative elements provides benefits for girls personally and intellectually. Art itself increases self-confidence by giving them the motivation to try new things. When applied to science we can see how art can further inspire confidence by teaching girls to think out of the box and innovate.
4. **The engineering design process reinforces girls' STEM identities by giving them the role of an engineer through all phases of product creation.** It can be challenging for girls to develop their STEM identity when they do not have a good grasp of what engineers do. As a result, we found that it was important to bring in the engineering design process throughout the span of our workshops. We planned our agenda to actively bring the participants through the process through project-based learning. . By giving the students a way to go through the processes engineers use on a regular basis, it would not only give them a greater understanding of what engineering is, but how to think like one, and see themselves in that role.

Design Your Own Birdhouse: A Workshop for Camp Reach

Our final workshop, "Design Your Own Birdhouse," will span for four days to include a day for research, design and prototyping, introduction to CAD, CAD and machinery, and assembly and reflection. Throughout the workshop, participants will gain new technical skills, learn collaboration skills and use their creativity. To complete the workshop we recommend the Higgins Computer Lab for CAD instruction, Foisie and Washburn for laser cutters, and Foisie for

assembly. By the end, students will learn about the design and manufacturing fields of Mechanical Engineering, how to develop a project through phases of ideation, prototyping, and completion using the engineering design process, how to translate a prototype to CAD on SolidWorks, and communication and listening skills by working in teams. The breakdown of our workshop days is shown below and are in further detail in Appendix G.1.

1. **"Introduction with Research, Design and Prototyping"**: Students will be working in teams to go through the beginning of the engineering design process: research, design and prototype. The prototyping phase will include a hands-on component that focuses on measuring parts and creating realistic models to get students prepared for the CAD on SolidWorks.
2. **"Introduction to CAD"**: This day will be a smaller workshop segment designed to get students first situated with CAD. Students will be working with staff to set up accounts to save their projects, then start with an introductory lesson that first gets them familiar with SolidWorks.
3. **"CAD and Machinery"**: Students will be working individually to CAD pieces that were designed by the group. Then, they will come together to cut them out using a laser-cutter. This will bring the balance of teamwork and individual skill development. On this day, they will be given a CAD lecture and support from their team and staff throughout the CAD process. In the middle of that, they will also have a chance to learn about and view the makerspace and the laser cutter that their parts will be cut out on to learn about the manufacturing side of Mechanical Engineering. Students will have a chance to get machine training, but staff will primarily play a role in cutting out the parts.
4. **"Assembly and Reflection/Discussion"**: By this day, students will receive the parts that were cut out for the birdhouse and will work with staff and their teams to construct their birdhouses. Following, there will be a chance for teams to reflect and discuss their progress, and work. During this time, students will be provided art supplies to decorate their birdhouses.

By the end, students will learn about the design and manufacturing fields of Mechanical Engineering, how to develop a project through phases of ideation, prototyping and completion using the engineering design process, how to translate a prototype to CAD on SolidWorks, and communication and listening skills by working in teams.

Recommendations

Throughout the process of designing the workshop, we have developed recommendations that are in addition to the workshop agenda, makerspace, material list, and learning outcomes.

1. **Test the timing of the workshop.** Due to the COVID-19 pandemic, the team was unable to have a run-through of the workshop from start to finish. To ensure accurate timing in CAD and the makerspace, a practice run of the workshop would be recommended. Ideally, this would be done with at least one team of participants. This way, certain time adjustments to the workshop agenda can be made before Camp Reach is in session.

2. **Use pre-and post-surveys to assess the success of the workshop and identify areas for improvement.** In order to see the impact of the workshop, we recommend including two anonymous surveys for the camp participants to take: one before and one after the workshop. Questions could include a scale of 1-10 of how well the participants understand the engineering process, how comfortable they feel prototyping if they feel that their opinion has been valued, and more. These questions could be answered before and after the workshop to gage if the participants felt as if they learned more about engineering from the workshop, and if they felt as if they were supported and that their voices were heard throughout the workshop. Using a before and after survey ranking system will allow for quantifiable data that will help with inclusion practices going forward as well as understanding how the workshop teaches engineering.
3. **Increase attention to diversity and inclusion in staff training.** No single workshop will make the whole program inclusive; therefore, our team recommends a way we can improve inclusivity in our workshop even just a little bit, is through staff training. Camp Reach used to have a day and a half for staff "diversity" training. The training focused more on how to be good role models for the participants, rather than inclusion. Our team wants to ensure positive STEM relationships between participants and staff members because it was shown to be beneficial to the inclusion and engagement of URM participants. During our focus group, our co-designers expressed their frustration with feeling excluded and being bullied by classmates and staff because of their gender and color of their skin. They felt like their ideas were not acknowledged, their opinions were belittled, and felt hurt and not wanted. One of the girls said people tend to not talk about racism and discrimination because conversations like these can be uncomfortable, especially for white people. Staff needs to feel comfortable talking about difficult topics like race because people's identities impact how they experience the world. Being able to acknowledge that and address needs that come with those unique experiences is essential for inclusion and positive engagement.

This is why our team recommends Camp Reach staff members and leaders to be trained and educated more on diversity, and learn how to address bias. Specific inclusion training for staff members can be a good way to address biases, it can be especially helpful to teach different ways to identify and deconstruct biases we have on our own without knowing, before participating as leaders at Camp Reach. In addition, we also suggest more in-depth training to understand what different racial, gender, sexuality, and ability groups need because understanding the intersection of people's identities is another aspect of inclusion. Our team recommends talking to the Inclusion Office for more information on anti-racism training and safe zones.

Authorship

Meghan Hendry, Aleksia Karapanco, Marisa Maltais and A. Ungerer contributed to the report sharing responsibilities of research, writing and editing.

When writing each section, as a team, we would break down what was needed divide those subsections among the members to research or write individually. Afterwards, all team members would work on the editing portions. Here is a more detailed breakdown of how the initial writing portion was divided:

Meghan Hendry wrote part of the introduction chapter, parts of the background information chapter on underrepresentation in STEM and STEM programs, part of the methodology chapter, part of workshop development chapter on design principles, and was the primary organizer and writer for recommendations in the conclusion chapter.

Aleksia Karapanco contributed by writing part of the introduction chapter, parts of the background information chapter about youth voice and inclusion, part of the methodology chapter, part of workshop development about design principles, and design alternatives and selection, part of conclusion chapter about design principles and recommendations, and part of the executive summary.

Marisa Maltais's role in the paper was to write part of the introduction chapter, parts of the background information on inclusion and diverse learning methods, part of the methodology chapter, parts of workshop development chapter on design principles and makerspace alternatives, parts of the conclusion about the project overview and recommendations and part of the executive summary.

A. Ungerer's contributions included writing part of the introduction chapter, parts of the background information chapter on middle school development and STEM concepts, parts of the methodology chapter, parts of workshop development chapter about brainstorming, criteria and final design, part of the conclusion about deliverables, abstract and authorship.

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1. Introduction

Women are underrepresented in science, technology, engineering, and mathematical (STEM) fields, making up just 28% of the science and engineering workforce (National Science Foundation, 2018). In addition, there is also a lack of racial diversity in STEM. In the United States Hispanics, African Americans, and Native Americans make up 27% of the population age 21 and older but only make up 11% of workers in science and engineering occupations (National Science Foundation, 2018). Diversity is an essential component in STEM fields where a problem may need diverse viewpoints in order to find the best fit solution (Corbett and Hill, 2015). However, fostering interest in STEM does not always occur immediately, and needs to be done over time to encourage students, especially women and under-represented minorities (URMs), that they have a place in an area of a STEM field, that they could fit in (Lyon et al., 2012). In a 2015 study it was found that students in middle school are already thinking about their future careers and that gendered norms were influencing their way of thinking. Students at this age don't have any experience from the real world and their career knowledge tends to be prone to stereotypes. For this reason, there are programs that engage students at the middle school level, where girls are most impressionable as they navigate through social norms, peer pressure and stereotypes (Shapiro et al., 2015).

Camp Reach, hosted by Worcester Polytechnic Institute (WPI), is a program for middle schoolers in Worcester, MA that seeks to bridge the gender gap in STEM by teaching girls how to think like engineers and give them the confidence to solve problems. Annually, 30 girls are accepted into the two-week summer program. Camp Reach was designed with the intent to help girls realize their self-efficacy in STEM through hands-on workshops, providing them with STEM support by introducing female role models and peers, which teaches girls that engineering majors can provide opportunities for humanistic and people-oriented work. (Demetry & Sontgerath, 2020)

In 2020, the Office of Pre-Collegiate Outreach was interested in making some changes and improvements to Camp Reach. Our sponsor, Sue Sontgerath, had previously thought of moving Camp Reach from 7th to 8th grade. Camp Reach's two-week residential timespan is more appropriate for the 8th grade age group and the Office of Pre-Collegiate Outreach is interested in creating a new week-long program for 7th graders. In 2020, the COVID-19 pandemic occurred that prevented the incoming 7th grade girls from being able to participate. The pandemic provided the opportunity to move the camp to 8th grade while still allowing the girls who applied pre-pandemic to participate. Along with the change in grade from 7th to 8th, the Office of Pre-Collegiate Outreach would like to consider a new workshop that utilizes WPI facilities. Many of the workshops have not been modernized to reflect the changing environment of the facilities at WPI. WPI has many spaces on campus that include state-of-the-art equipment such as laser cutters, rapid prototype 3D printers, and tools to create and work on projects. The Office of Pre-Collegiate Outreach is interested in using these spaces to expose girls to new equipment and be able to work on a project from design to prototype.

The Pre-Collegiate Outreach Programs Office would also like to improve upon the inclusivity of workshops to support the diverse populations of camp participants. Despite the adjusted lottery selection for Camp Reach, applicants and participants have historically been dominated by white and Asian girls, so diversity has been limited. In a study examining engineering recruitment outcomes, 71.8% of the 419 Camp Reach alumni were white, 6.7% were Asian, while 13.8% were underrepresented minorities such as Hispanic and Latina, African American, and Native American (Demetry & Sontgerath, 2020). There is a clear gap in representation between white and Asian, and URM girls. Among the URMs that do participate, the outcomes for these girls pursuing STEM in the future are not as strong as those of white and Asian participants.

The goal of this project was to design a multi-day workshop for Camp Reach that utilizes WPI makerspace facilities to create a sophisticated experience for 8th grade girls and is designed to promote inclusion. The workshop will be a few days long with the use of machinery and will have the girls work together as a team during the research, planning, and design portion of the workshop. At the end they will personalize and present their designs on their own. This report provides an overview of Camp Reach, what is known about women and URMs in STEM, best practices in STEM activities, and promising strategies for inclusion. We also review the steps we took to create a workshop and the findings we made throughout the process.

2. Background and Literature Review

In this chapter, we will explore the underrepresentation of racial minorities and women in STEM, the importance of middle school years and intervention, how to incorporate youth voice and STEM concepts into programming, and the successes and challenges Camp Reach has seen throughout the duration of the program.

2.1 Underrepresentation of Women and People of Color in STEM

The representation of women in STEM fields has increased compared to the past however, there is still a disparity between men and women. As seen in Figure 1 below, women make up 50% of the college-educated force and 28% of the science and engineering workforce. Within the science and engineering fields, 60% of women go into social sciences, 48% in life sciences, 15% in engineering, 28% in physical sciences, and 26% in mathematical and computer sciences. (National Science Foundation, 2018)

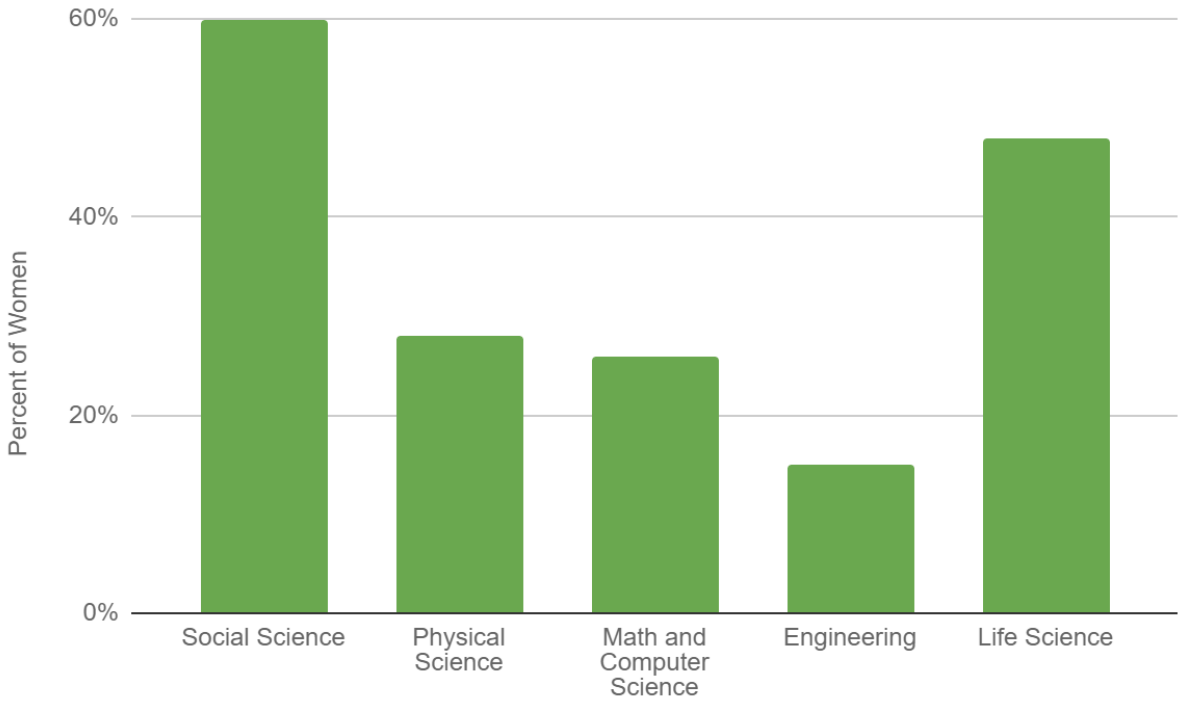

Figure 1: Representation of Women Employed in STEM Fields in 2018
Data Source: Science and Engineering Indicators, National Science Foundation, 2018.

We can see that even though a college education is equal between men and women, fewer women go into STEM careers, and even fewer women are focused on mathematics, physical science, and engineering than in other fields within that domain. There is also an

underrepresentation in minorities in STEM. As seen in Figure 2, under-represented minorities (URMs) make up a smaller proportion of the science and engineering workforce at 11% of workers in science and engineering occupations, but they make up 15% of the highest degree holders in these fields. URMs are defined as Hispanics, African Americans, and Native Americans. (National Science Foundation, 2018)

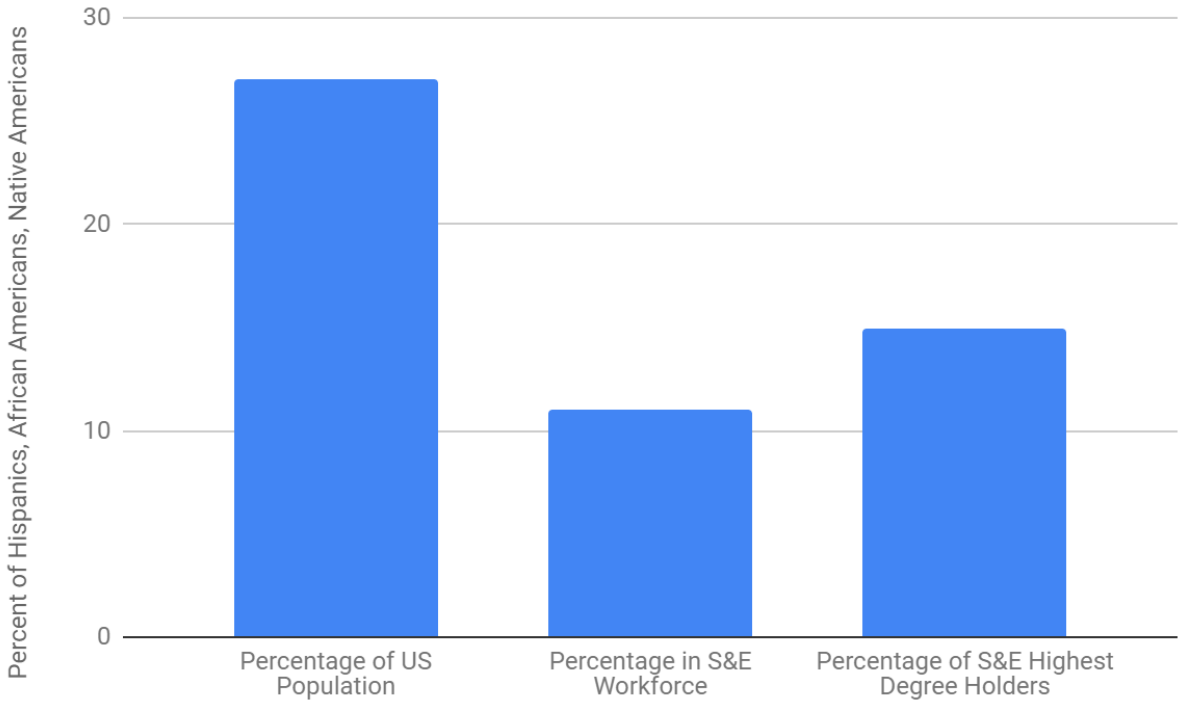

Figure 2: Representation of Minorities in US Population compared to Science and Engineering Professions in 2018
Data source: Science and Engineering Indicators, National Science Foundation, 2018.

The lack of diversity in gender and race ends up playing a major role in the workplace when students get to that level in their career. In the STEM workforce, there are a lot of team projects where women or URM women may have to solve a larger problem whether to improve a product or help a community. When working on collaborative assignments, there is a great need for different interpretations or perspectives of the problem, which is necessary to critically think and eventually solve the problem at hand (Lamm et al., 2012). This is because problems presented may be multifaceted and require different backgrounds and experiences in order to create a better rounded solution von (Von Bergen & Collier, 2013). For example, someone who is Asian may better understand the values of Asian people and could suggest that a product may not serve them because it contradicts with those values, thus lessening the reach of the solution. By having that input, engineers are challenged to perform with empathy and create broader solutions

that can actually impact communities. Highly diverse teams can untangle complex problems that intersect cultural differences by using their experiences and background.

2.2 Barriers for Women and Underrepresented Minorities

There are so many barriers that women and underrepresented minorities face, that comprise the social norms that prevent women and URMs from being exposed to STEM early on. In a study from the Journal of Research in Technical Careers, it was found that some of those social barriers women face include male domination in fields, lack of awareness in opportunities, work-life balance, treatment of women, and focus on boys in STEM toys (Swafford & Anderson, 2020). From these reasons, it is evident that this is a systemic problem that lies in the way we introduce women to STEM at an early age and encourage them through their education.

It's also important to realize that women and girls are not a homogeneous group. When factoring in representation, we have to understand that for some URMs, socioeconomic status can play a role in involvement in STEM. In some situations where URMs live in underserved locations, there can be a gap in knowledge of sciences and math because schools are most likely less funded and have fewer resources to support studies and student enrichment. A study by UCLA discussed this barrier when it came to students going to college and pursuing STEM. The completion rates of Hispanic and Latino, Black, and Native American students in completing STEM degrees were only 15.9%, 13.2%, and 14.0% respectively (Abdul-Alim, 2013). When students are provided with fewer resources and are unable to complete basic math classes like algebra in middle school, they will most likely not be able to take calculus in high school, which can be a large barrier to getting interested in STEM and being accepted into those degree programs when applying to college.

2.3 Importance of the Middle School Years

It is important that we engage students at an early age to set students up for their high school careers and college decisions. According to the Association for Middle Level Education (AMLE), researchers took a survey of 1200 middle schoolers and found that there were already gendered ideas of STEM careers; girls found themselves to be aligned with artistic and educational careers while boys saw themselves in STEM careers. Further, girls also tended to see STEM careers more suited to boys (Shapiro et al., 2015). These ideas can be rooted in the way girls are raised and taught to solve problems but can be changed, especially at an age where they are impressionable through projects, mentoring, and exposure.

Middle school years are crucial to exposing young girls to STEM because it helps them practice their math and science skills, it broadens their perspectives on STEM, and it helps them promote a holistic approach to STEM which will lead them to choosing STEM careers in the future. In a study done at Oklahoma State University, middle school students participated in an after-school engineering program that changed their way of thinking about engineering from fixing things to "creative problem solvers who work to help people and improve the world" (Hammack & High, 2014). This mentality broadens student's perspectives on STEM and can

foster an interest because students have a better idea of what engineers do. Further, supporting girls in STEM education helps to make that interest into a meaningful experience and possible career. In a 2014 conference it was mentioned that integrating engineering design into a K-12 classroom through age-appropriate education and skill development helps to promote a holistic approach to STEM and will lead to more students choosing STEM careers in the future (Richards & Donohue, 2014). Integrating these engineering experiences makes it important for students to see themselves in those fields. Students who become engaged in an aspect of STEM sought to go deeper into those fields and viewed engineering experiences as a good way to practice their math and science skills (Alemdar et al., 2018).

It is important that girls also get the same early support and exposure to STEM opportunities as boys. In another study, girls who participated in Girl Scouting programs helped to expand their interests in doing typically male-dominated careers and increased their confidence when pursuing those (Shapiro et al., 2015). This is because girls have the chance to be exposed to different activities in Girl Scouts such as science and robotics. When girls are able to get hands-on during activities, it helps to break down those gendered ideas of STEM because girls can see themselves in the place of boys they usually see in those roles.

2.4 Camp Reach at WPI: Program Design, Successes, and Challenges

Since 1997, WPI has hosted Camp Reach which is a two-week summer STEM program for girls now entering 8th grade, located in Worcester, Massachusetts. Camp Reach's goal is to bolster girls' interest in STEM, teach girls how to think like engineers, and give them the confidence to solve problems. A total of 30 girls are accepted annually to the program through a lottery system. The program includes hands-on workshops, field trips, and community service projects. Camp Reach has the following design principles that embody values that are important to fostering girls' education during and after their program:

1. **Provide an engineering experience for girls.** The program purposely focuses on engineering problem solving and design more so than science and mathematics.
2. **Challenge and support participants with multiple, hands-on engineering design experience**. The goal is to build engineering self-efficacy which refers to confidence in one's ability to successfully perform a task. In order to do this, Camp Reach girls participate in multiple hands-on experiences in multiple engineering domains throughout the two-weeks.
3. **Utilize a wide range of female STEM role models and peer support.** The goal is to have positive role models and peers that can serve as important social support for the girls. Peer influence becomes strong in middle school, so it's important for the girls to feel uplifted and supported by the Camp Reach role models.
4. **Show how engineering provides a range of opportunities to fulfill humanistic and people-oriented values and goals.** Girls compared to boys, place more importance on having a job that can make the world a better place. The goal is to show the girls that

engineering majors and careers provide opportunities for humanistic and people-oriented work.

5. **Include programming for parents.** The goal is give the parents concrete examples of how to talk about STEM with their daughters and methods for creating a STEM-friendly home. This way the girls will feel more confident and supported by their parents to invest their time in STEM.
6. **Facilitate multiple touchpoints after the two-week summer experience.** The camp invites girls to return to campus twice annually which includes a mix of social and STEM activities. The goal is to have ways for program alumni to connect and network which brings positive change for the girls by helping to prepare students in making future decisions about their STEM careers.

By using these design principles, Camp Reach has been successful in exposing girls and bringing them into STEM majors. In a study of the impact of STEM intervention at Camp Reach, 15.3% of Camp Reach girls pursued an engineering major and 35.4% pursued a STEM major compared to the control group where 9.1% pursued an engineering major and 29.6% pursued a STEM major. (Demetry & Sontgerath, 2020)

However there is still an issue about diversity and inclusion in the Camp Reach programs as Asian and white girls are more likely to pursue engineering degrees. The pursuit of engineering degrees by ethnicity for past Camp Reach participants is 18.2% Asian girls, 16.8% white girls, and lastly 5.1% of URM girls. The pursuit of STEM degrees by ethnicity for past Camp Reach girls is 59.1% Asian girls, 38.0% of white girls, and lastly 12.8% of URM girls. This may be because the original design of Camp Reach was considering a homogenous group of girls without regards to the barriers that girls who are URMs can face. Although Camp Reach has made efforts to bridge that gap in diversity through financial assistance and reaching out to community-based organizations, there is still a lot of work to be done to promote diversity and inclusion in the program and fully embody the principles Camp Reach values. (Demetry & Sontgerath, 2020)

When referring to diversity, we reference the individual differences such as personality learning styles, and life experiences, and group or social differences such as race/ethnicity, class, gender, sexual orientation, country of origin, physical or cognitive abilities, as well as cultural, political, religious, or other affiliation, that can be engaged in the service of learning (“Diversity Equity and Inclusion (DEI) Terminology”, 2021). For inclusion, it is the active, intentional, and ongoing engagement with diversity in people, in the curriculum, in the co-curriculum, and in communities (“Diversity Equity and Inclusion (DEI) Terminology”, 2021). Given the data regarding racial breakdown, Camp Reach may lack resources in inclusion because of the lack of diversity. However, Camp Reach aims to increase both diversity and inclusion despite the complexity in doing so because of the value of diverse workplaces and the importance to give all girls an opportunity to participate and succeed in STEM (Demetry & Sontgerath, 2020).

2.5 Incorporating Young People's Voice

An important principle for inclusion and effectiveness of youth programs is to incorporate youth voice in program planning. Many young people want to be heard and be a part of change by being involved in planning their future. They have new ideas and different perspectives than those of adults, which can help shape the future that they want to live in. In a 2001 report, it was shown that although increasing numbers of youth are involved in different programs, many were unsatisfied with their experiences (Fredericks,et al., 2001). Youth voice is a mechanism for individuals to express their own feelings realities and by doing so they realize that they themselves are the experts concerning their own experiences and needs. However, the voices of underrepresented minorities are often missing and their authentic lived experiences are misinterpreted. Incorporating voices of young people that have traditionally been underrepresented is essential to better understanding the diverse experiences within these groups (Cunningham & Rious, 2015).

Youth voice is an essential part of successful programs because it requires young people's active involvement in planning, implementing, and problem solving while incorporating their experiences as youth (Fredericks,et al., 2001). In a study done in Youth Hub, a grassroots, community-based initiative based in Boston, MA, Youth Hub used youth voices to create change across the city. Their mission was to empower young people and use their voice to eliminate barriers to success for young URM students in Boston's neighborhoods. Young leaders worked in collaboration with businesses, government, and other communities to identify and address critical youth needs. By getting their input and valuing youth contributions as valid and equal, Youth Hub was able to strengthen the voice of the youth, and promote positive social change in the community (Gardner et al., 2019).

By engaging young people they become aware that their voices can create effective change in their communities and their school, which results in participants building self confidence. When a program promotes a meaningful involvement for young people, they have opportunities for connection to others, feelings of empowerment, and self-discovery, which can lead to positive development. Youth voice allows participants to be respected for their ideas and contributions and they feel free to state what is on their minds without feelings of judgment. When students have a platform for their voices to be heard, feelings of connection increased and students felt that they belonged more. (Mitra & Gross, 2009)

2.6 Integrating STEM Concepts and Practices Into Learning Activities

In addition to adding youth voice, learning from other STEM programs is important to take into consideration for programming planning. Many studies have recommendations to form better results from program designs. Integrating these recommendations and learnings will make the design stronger.

2.6.1 Project-Based Learning in Girls' Education

Project-based learning holds promise for influencing girls to pursue STEM careers following their experience. Project-based learning (PBL) has been implemented in many programs throughout the education system. PBL is a student driven instructional strategy that focuses on collaboration, interdisciplinary work and is technology based (Han et al., 2015). For both girls and boys in middle school, it has been shown that implementing PBL has positively influenced them (Han et al., 2015). Some of the positive influences include developing attributes such as learning, team communication, and collaborative behavior. These developing attributes were found in a case study that examined two middle school fabrication laboratories called FabLabs that used problem-based learning on teams to see how students collaborate and interact as well as how the teacher-student interaction occurred in the classroom (Chan & Blikstein, 2018). In addition, after a PBL experience at a school, the percentage of girls who wanted to get into STEM careers went from 35.9% to 41.2% (Christensen & Knezek, 2017). Boys typically have more interest in STEM fields and careers, but girls responded better to projects and increased interest following that experience (Christensen & Knezek, 2017). Overall, adding a PBL experience does work for engaging girls in STEM.

2.6.2 Other Key-Factors in Successful STEM Activities

Explanation of key concepts before an activity and connection to STEM concepts are imperative for a successful workshop. In a 2017 study in Taiwan for integrating engineering design practices in a high school technology education, students first had instruction from teachers before completing a design project. The students learned about units that would help them in the project of designing a mechanism toy. After the first four weeks of learning the units, the students had six weeks to construct a toy with mechanical structures using LEGOs and the materials their instructors provided. The units had hands on models that were also made out of legos and also showed animated computer-aided design (CAD) models of the mechanisms. These helped explain the application of the mechanisms and STEM background to the students so that there was a clear understanding of the connection to STEM concepts. The students were able to work hands-on and put the models together themselves. This allowed the students to gain a better understanding of the way the mechanism functioned. The important takeaway from this is the explanation of key concepts before the activity which lead to a more successful design. It is also important to make the connection to known STEM concepts relevant to student's education so they can see the relationship between STEM knowledge from school and the engineering process. (Fan & Yu, 2017)

It is important to note that some integrations of STEM programs need to be altered for the school or setting depending on the population and in respect to the learning curve of the activity. A Minnesota middle school implemented Gateway to Technology from Project Lead the Way (PLTW). They found that the course from Gateway to Technology took 2-3 times longer than the course had accounted for due to confusion on the teachers and students parts (Stohlmann et al., 2011). It was also found that STEM programs in general could be made stronger if the

connection to engineering practices, or STEM in general, was more explicit (Guzey et al., 2016). These impressions of this middle school experience and what can be done better in regard to connection to STEM applications and timing, can help when developing STEM programming.

In addition to studies, there are also planning tools that exist to help create a successful STEM program. The Dimensions of Success planning tool allows educators to plan a high quality STEM workshop or activity for participants. The tool was designed by The Partnership in Education and Resilience (PEAR) Institute to help after-school youth STEM programs increase the quality of STEM learning, however, it has been applied to in school programs as well. The dimensions consist of:

1. **Organization.** Plan time allotted and materials for the activity accordingly.
2. **Materials.** Have materials that are safe to use and hold the attention of participants and help reach the STEM goal of the activity.
3. **Space utilization.** Use a space that will be compatible with the activity.
4. **Participation.** Allow every participant the opportunity to participate in each activity. Help students who are disengaged become engaged.
5. **Purposeful activities.** Create a learning goal and ensure that the activity has steps to help participants reach that goal.
6. **Engagement with STEM.** Allow participants to share their thinking and understanding of the activity and provide a hands-on activity.
7. **STEM content learning.** Have participants make ideas and connections to STEM on their own as well as prepare STEM ideas beforehand. Avoid giving participants all the information.
8. **Inquiry.** Allow participants to partake in real-world STEM professional practices.
9. **Reflection**. Ask participants open-ended questions to guide them in their learning throughout the activity.
10. **Relationships.** Develop and encourage positive relationships between participants, peers, and staff.
11. **Relevance.** Discuss with participants why the STEM content is relevant and important to themselves, their communities, or society.
12. **Youth voice.** Allow ownership of participants in the activity. Allow participants to make their own decisions and allow them to share their ideas.

When creating a STEM activity or workshop, the dimensions allow you to develop a workshop with greater learning outcomes. Programs that implement these dimensions will have greater success in teaching STEM to youth. (PEAR Institute, 2017)

2.7 Promising Strategies for Inclusion of Diverse Populations

Truly successful STEM programs include promising strategies for inclusion. This is necessary to include diverse populations because inclusion and diversity work hand-in-hand, and are effective in encouraging URM girls to pursue STEM careers. Racial and gender-inclusive programs — where students are selected by interest in the STEM field rather than by competitive

selection such as a high GPA or achievement—can help underrepresented students overcome barriers and give them the resources needed to succeed in STEM (Means et al., 2017). We will look into some of the strategies that work and analyze how the strategies affect URM girls' education, and the financial, emotional and academic needs to inspire and encourage them in STEM fields (Means et al., 2017).

Project Exploration, a non-profit education organization in Chicago, has shown success in making STEM accessible to minorities and girls. Past participants of Project Exploration were more likely to graduate high school, enroll in college, as well as major in STEM compared to peers (Lyon et al., 2012). Project Exploration's design principles consist of:

- **Equity.** Making STEM accessible for all.
- **Relationships.** Staff takes on a personal approach and supports students through long term relationships.
- **Students at the center.** Students help create the curriculum based on their interests. Activities are presented in a manner that makes STEM accessible for all.
- **Access to experts.** The curriculum is primarily taught by STEM professionals. The professionals career path and individual experience is shared throughout the process.
- **Meaningful work.** Students work on a public project throughout their experience in the program.

These design principles were created with the youth in mind who are least likely to get involved in STEM. Students at the center of the focus of the curriculum helps cultivate the youth voice which helps grow participants' curiosity in different STEM topics. (Lyon et al., 2012)

2.7.1 Supporting Financial, Emotional and Academic Needs of URMs

Underrepresented minorities face many social and economic pressures during their journey to achieving a higher education, which impact their plans for pursuing a STEM major. This is why STEM groups that intend to uplift girls who are URMs need to tailor their experiences and curriculum to factor in these needs. A way to support diverse needs to URMs is to provide spaces where students can create lasting, positive relationships with mentors. These relationships include having a mentor that students can go to for advice throughout their education. This way they can have access to someone who is able to give them resources to succeed and also act as a role model to them. Role models often lead to inspiration for students to be able to pursue the career they desire and are able to be problem-solvers in the future. (Estrada et al., 2017)

In a ten year study of Project Exploration, an organization in Chicago that makes science education accessible to URM students, it was discovered that relationship-based programs with lasting relationships help foster growth in STEM programs which can help influence URM girls to pursue STEM in the future. (Lyon et al., 2012). Students who participated in Project Exploration liked having access to professional help and resources beyond the program. Additionally, learning STEM skills and being recognized was helpful in the program because it led to self confidence for the URM girls. Another study performed at STEM-focused high school

supports the study from Project Exploration by suggesting that relationship-based mentorship for Latino and Hispanic students is incredibly beneficial to provide additional resources and advice that may not be available otherwise (LaForce et al., 2019).

Another strategy is creating race-specific programs for students to support other students that look like them. I AM STEM is a program that creates a safe space where Black girls are empowered to be themselves and encouraged to explore different STEM fields. A study showed that after participating in the program, the girls actively continued their STEM engagement throughout the school year by joining STEM clubs in their schools, which further influenced their future plans (King & Pringle, 2019). Another study suggested that Hispanic and Latino students value student culture (LaForce et al., 2019). Student culture is defined as "student trust & respect, student code of behavior and values, and how students contribute to school decision-making" (LaForce et al., 2019). Student culture also has a big impact where students who can see others like themselves pursuing and challenging themselves, may feel inspired to also challenge themselves. This support has enabled students to be more confident in their own scientific abilities (LaForce et al., 2019). From these studies , it is clear that there are strong STEM education outcomes from race-specific programs. These programs provide culturally-relevant support which could include access to advice, personal connections, resources and opportunities.

Additionally, academic support is necessary starting from early years. Experts say one of the most effective ways to support minority students, is to provide coursework in middle and high school to give students a sense of what STEM courses entail. Minority students might not know that the sciences require more study time on average and may be unable to find that time to study because of other challenges that might be taking place in their lives. Hence, many students start in the sciences and later switch out. This is why exposing them early to STEM courses will help them in the long run so that they can develop critical thinking skills and learn how to study while maintaining the other responsibilities they may face. (Abdul-Alim, 2013)

Racially inclusive practices in education, allows for better learning outcomes for students of diverse backgrounds. A study with 2000 6th graders coming from ethnically-diverse and low-income communities showed that students felt safer, less harassed, and less lonely in their classrooms in comparison to students who were not able to experience intentional inclusion. Students' self-worth was rated higher with increased ethnic diversity. Being in a diverse classroom had the best outcomes for Latino, Hispanic and African American students. This goes to show how important diversity is in STEM fields. It makes students feel more comfortable being themselves, and it decreases their fear of conforming to a negative stereotype about their racial group. (Juvonen et al., 2006)

2.7.2 Using Generalized Inclusion Practices

Inclusion practices are guides used by students and educators to create a safe learning space and environment that encourages girls to share ideas and participate. Through looking at other programs, we found these practices that have showed positive results in other spaces:

- Using mentorship to provide representation, guidance and community
- Engaging multiple learning styles with diverse teaching methods
- Engaging underrepresented minority voices

To do this, certain things need to be taken into consideration such as barriers that may cause the girls to not feel included. One barrier is representation of URMs in the STEM field. According to "Teaching Tolerance", an article about women in the STEM pipeline reports that "Caucasian girls (61%) are more likely to know someone in a STEM career, compared to African American (48%) and Hispanic (52%) girls" (Waldrop, 2015). While keeping these statistics in mind, we can think of potential ways to show representation of URMs.

A form of providing some representation could include some sort of mentorship for the girls. In a paper where a Black women faculty member shared her experience in a program called Sisters of the Academy (SOTA) Research Boot Camp, it was found that mentorship helped her gain confidence and friendship within the academia community. While this woman is not in the same age range as the middle school girls in this camp, the conclusion of this paper mentions improvements of engagement and individuality after participating in this program. To connect all the girls to engineering, bringing in an aspect of mentorship may be a way to bring inclusion into this workshop. (Davis et al, 2011)

In education, inclusion is an important aspect of lesson planning. At the Center for Teach Excellence at UVA, it is emphasized that while teachers create lesson plans or programs it is important to consider how inclusion is embedded within the classroom. Ways to do this include utilizing different teaching methods, such as broad analogies, having several correct answers to questions and to use a variety of teaching tools (Wheeler, 2017). The use of a variety of teaching tools provides opportunities for girls to learn and get engaged where they wouldn't with a singular method of teaching. As a result, girls may feel more comfortable sharing their ideas and contributing since different teaching tools will allow some to gain a deeper level of understanding of the material learned.

In addition, researchers rarely examine middle school URM girls' experiences from their own perspective. Students of diverse backgrounds are so often struggling to find someone willing to listen to their voices, which is why it is so important to engage the voices of URM girls by giving them the platform to share ideas developed from their unique experiences and perception of the world. Doing so will make them feel welcomed and accepted in their environment, and give them the freedom to further develop their identities. (Cunningham & Rious, 2015)

3. Methodology

The goal for our project was to design a multi-day workshop for Camp Reach that utilizes WPI makerspace facilities to create a sophisticated engineering experience for 8th grade girls and is designed to promote inclusion. In order to achieve our goal, we created the following objectives:

- Incorporating youth voice in the design process
- Identifying best strategies that promote inclusion
- Designing the workshop through phases of ideation, selection, and development

In this chapter we discuss the methodology we developed to obtain these objectives and how we analyzed the data gathered to create a workshop.

3.1 Incorporating Youth Voice in the Design Process

An important decision for our methodology was to involve middle school girls in the design process. Previously, Camp Reach workshops have been designed by faculty, staff, and undergraduate students. Due to this reason we wanted to include youth voices.Youth voice goes beyond just having children give their input, but acknowledges their perspectives as people who can understand and contribute (Rahm et al., 2014).

We incorporated that youth voice into our project by creating a focus group of students. A focus group was used because in the context of this project, the girls who participate at Camp Reach will be part of a project experience and collaborate with each other (Morgan, 1996). By participating in this research with us, they were also collaborating for this project. Further, we wanted to build a sense of community so girls were able to open up to us and to each other, and ease tension and stressors in the room by providing a space where there were more students than researchers.

Considerations for focus group composition included the number of participants, age, and race/ethnicity. We wanted the focus group we created to consist of eight to ten middle school girls. Ten was an ideal number for a focus group because it is small enough for girls to be able to gain comfort and familiarity and have meaningful discussions, but large enough so that we could have diverse perspectives, which is an important focus of our workshop (Franz, 2011). We asked middle school girls to participate since they are our intended audience and we wanted to know their experience in being in middle school. To accurately reflect the diversity in Worcester, we invited URM students from Worcester Public Schools in middle school to join our focus groups. It was decided to only include the URMs because it was already shown that Camp Reach is successful in supporting white and Asian girls.

To recruit participants we had to contact middle school girls via email, create a consent form, and create a recruitment message. Our sponsor and project advisor Suzanne Sontgerath is the Director of Pre-Collegiate Outreach Programs at WPI. She assisted us in providing contacts to obtain our focus group from a list of students that are on the Pre-collegiate Outreach mailing list. This meant that the girls had participated in a STEM program at WPI or were interested in participating in a program. We then created a consent form for middle school students to obtain

them and their parents' permission to join the group. It included descriptions of the purpose of the project, what types of questions we planned to ask in each stage, the dates for each phase, the setting of the focus group, and any risks that could be involved. The consent form was emailed to the girls with a recruitment letter detailing the focus groups. An incentive of $50 for participating in the focus groups was included within the consent form and letter. Before presenting to the students, we asked the Institutional Review Board (IRB) for approval for testing on human subjects. Through the IRB, we developed a consent form that we used when recruiting students. Along with the consent form, our team created a recruitment letter that was sent with the consent form attached. All materials were approved by the Institutional Review Board (IRB). The approved IRB materials can be found in Appendix C.

Of the thirty girls we emailed, nine emailed us that they were interested. For the first focus group we had eight girls participate and for the second focus group we had six participants and one come in late, and seven participants in the third focus group. Of the nine participants, four identified as African American, three as Hispanic or Latino, and two identified as African American and white. Of the nine participants two were 12 years old, six were 13 years old, and two were 14 years old.

Our focus group was involved in the inclusion, idea development, and testing process. Due to the COVID-19 pandemic, all meetings had to be done virtually via Zoom. Each of the three focus groups duration was 1.5 hours long. To prepare for the virtual focus groups we met with a social science researcher, Irene Shaver, who taught us what to prepare and how to guide conversations (Appendix D.1). The discussions were mainly done through the chat feature on Zoom since the girls felt most comfortable speaking to us in that way. Overall, providing a platform for URMs and giving them a safe space to discuss their ideas and provide a voice for their experiences was critical to incorporating culturally-relevant inclusion into our workshop.

3.2 Identifying Best Strategies That Promote Inclusion

We identified the best practices that can promote inclusion in STEM because we wanted to know what works and what we can implement in our workshop. We used our literature review, elicited experiences with inclusion from our focus group, and consulted with professionals. Throughout the process, we wanted to focus on finding practices that promote inclusion and specifically tailor those to URMs. This means that we needed to look into the societal problems that women and URMs face in STEM, then look into methods that WPI and other institutions have incorporated in order to level the playing field and give opportunities for women to succeed. Additionally, we interviewed professionals and held the focus group with middle school girls to understand how we could honor the girl's diverse backgrounds and what steps we could take to promote collaboration and racial inclusion in our workshop.

As mentioned in Objective 3.1, incorporating the youth voice of middle school girls throughout the process was important so they have a voice every step of the way. During the first meeting on Zoom, we first prompted our focus group through icebreakers by asking questions about their successes, interest in STEM, physical identities, and personal experiences in middle

school like their classes and projects they were proud of making. With this in mind, we continued our discussion in the route of underrepresentation of minorities and women in STEM through a statistics-based game that showed the barriers URMs face in pursuing STEM careers. Afterwards, we discussed those results while giving the girls a platform to articulate why interests did not align to the career choice and what barriers are present that contribute to that. After discussing systemic barriers, we shifted the conversation to personal and societal inclusion with questions such as the following:

- Describe a time when you have felt excluded from something? This can be an activity, game or experience. Why do you think you were excluded?
- What kinds of problems do you notice in the world, your home or at school?
- Have you ever had anyone treat you differently because of how you look? How does that make you feel? Why? What did you do about it?

These questions gave us a better understanding of what makes a space inclusive and how we could possibly structure our workshop ideas so that we could intentionally prevent excluding behaviors and actions. A more detailed version of the questions we asked can be found in the focus group agenda in Appendix D.2.

We also interviewed WPI faculty members on ways to promote inclusivity. We interviewed Shari Weaver who is the Director of a Teacher Prep Program and who has experience in K-12 education. We discussed what experiences she had bringing inclusion into her classroom, including English Language Learners (ELLs) who come from immigrant populations, and how effective that has been (Appendix A.2). In addition, interviewed Geo Interiano who is the Associate Director of Admissions for Diversity to ask him about his experience working at WPI, any successes his department had to increase diversity, and any strategies on how to maintain that through inclusion (Appendix A.4).

At the end of this objective, we analyzed strategies and practices that can be used to promote inclusivity, from multiple sources such as the girls in the focus groups, scholars, and WPI practitioners to produce a set of best practices to include in our workshop design.

3.3 Designing the Workshop Through Phases of Ideation, Selection, and Development

3.3.1 Consulting with Professors and Staff

The next step was to consult professionals in education and makerspace facilities to determine how we could create an 8th grade-centric curriculum for our workshop. Our Interactive Qualifying Project (IQP) advisors Chrysanthe Demetry and Suzanne Sontgerath recommended interviewing Shari Weaver, Sarah Jane Wodin-Schwartz, and Erica Stults.

Shari Weaver is the Director of the Teacher Prep Program at the STEM Education Center. Weaver has experience in K-12 curriculum for STEM and working with underrepresented communities. Through interviewing her, we gained experience in determining what makes content K-12 appropriate, how to implement that into a program, and what principles we needed

to implement into the program to keep it engaging. Additionally, we explored options for inclusive STEM curriculum and ideas on how to address URM needs within our workshop. (Appendix A.2)

Sarah Jane Wodin-Schwartz is a Mechanical Engineering professor at WPI. Her expertise was recommended by our advisors for her past involvement in Camp Reach and her experience in brainstorming ideas and creative thinking. We interviewed her to gain more ideas on what kind of programming we can do including project themes and ways to incorporate makerspaces. (Appendix A.5)

Erica Stults is the Interim Director of Makerspaces. With her expertise in CAD and Rapid Prototyping, we consulted her to come up with ideas on safe makerspace use and introducing design to prototype concepts while integrating machinery. We were also able to get more sources and contacts to fulfill the safety concern of each of the makerspaces we are interested in pursuing and the machinery available. (Appendix A.3)

All interviews were done informally with a semi-structured setting. The interviewees were sent questions in advance, before we had a discussion on Zoom with them. For our records, we used note-taking. All interview notes can be found in Appendix A.

3.3.2 Discovering Interests of Diverse Middle School Girls

Another important part of this project was consistently getting input from the girls who have the opportunity to participate in these activities. During the first focus group with these girls, we talked about their interests, education and perceptions of STEM to come up with project ideas.

We started the discussion by gauging their interest and priorities through introductions and icebreakers. They were structured to include talking about hobbies and interests, and opening a space for affirmations so that we can get a sense of what is important to the focus group. To solidify that, we asked the following questions in the discussion portion:

- **What is your favorite school subject and why?** This question helped us to understand what other topics besides STEM that girls were interested in, so that we could understand what overall topics we could incorporate for a workshop idea.
- **What do you think an engineer is? Draw what you picture in your head.** One of our workshop outcomes is gaining a better understanding of engineering and the design process. By using this question, we better understand what girls know about engineering, and have an idea on where we can share knowledge.
- **What are interesting topics that you have learned in math and science? Have you applied any of those to real life (e.g. projects, experiments, etc.)?** Using this question, we get a better sense of the academic themes that are interesting to girls, and it gives us an idea of what kinds of workshop themes would be interesting to them.
- **What kinds of problems do you notice in the world, your home or at school?** Similarly to the previous question, we look more into possible themes for the workshop, but aligning more to social or personal issues to also get a sense of what kinds of

solutions middle school girls would want to contribute to.

We then used these questions to develop multiple workshop ideas by looking at their academic, personal and social interests. The complete agenda for the first focus group meeting can be found in Appendix D.2.

3.3.3 Assessing Makerspace Facilities

Another piece of this objective was to incorporate WPI facilities in order to get the sophistication in the workshop we created. First, we researched WPI makerspace facilities. This included determining the following criteria:

- **Type of room**: We wanted to be sure that the makerspace chosen has machinery for making prototypes. We will not be using other facilities like biology or physics laboratories, or individual labs from professors.
- **Safety**: Safety was another important measure in Camp Reach because the camp works with 8th grade students; therefore, while researching we determined the risks, safety, and legal concerns for the 8th grade age group.
- **Maximum capacity**: Camp Reach typically serves 30 students. Adding the staff into the group, we looked into what capacity each room holds to determine how or if we needed to split up groups so that the maximum capacity of a room was not reached, and to ensure that each girl was able to have a fulfilling experience in the space.
- **Number of machines**: We needed to have enough machines in the room to cut out all the pieces we need, and for girls to use the machines if we choose to go that route.
- **Machine types**: We needed to know what machines were in each facility and the level of expertise needed. Although our workshop is supposed to be more sophisticated, the grade of students was an important part we needed to consider as 8th grade girls may not be ready to use very complex machinery.

To determine this, we researched WPI facilities first through information on WPI's website. Then we narrowed down the rooms and capacities through creating a list of places with the criterion listed for each space. We then decided to meet virtually over Zoom with Adam Sears, the Director of Foisie Innovation Studio Technical Operations, Innovation, & Entrepreneurship and James Loiselle the Senior Instruct Lab Technician of Washburn Shops to talk about the spaces we considered using. We talked to them because their spaces met the most criteria in the list. All makerspace materials, including makerspace list and the virtual tour notes can be found in Appendix B.

3.3.4 Framing Multiple Workshop Concepts

After the first focus group and assessment of makerspaces, each team member came up with multiple workshop ideas to create a large pool of ideas to consider. Each idea was first developed to include the workshop topic, how it relates to middle school girls' interests and . The multiple workshop ideas were created through analyzing the interests of middle school girls,

assessing makerspace use, conducting interviews with staff. This process led us to having eleven workshops to choose from.

3.3.5 Determining Which Workshop Would be Best Suited For Camp Reach

The eleven workshops were then narrowed down into four workshops. This was done by evaluating each of them against criteria we developed through looking into our focus group interests and needs, interview suggestions and our literature review. The criteria we found were feasibility within four days, compatibility with makerspaces, creative aspect incorporation, real world problem solving or application and age-appropriate curriculum.

After deciding four out of eleven workshop ideas, we developed each one more to create elevator pitches (Appendix E.2). Each elevator pitch consisted of what will be learned, designed, created and kept in mind how each participant could express themselves in each workshop idea. With this in mind, it was also important to describe expected flow of the workshop and any new skills or machinery that would be used.

In the second focus group meeting, we discussed each workshop idea after presenting each pitch with their corresponding slide. Each idea had the same format where the learning, design, create, assemble and express yourself aspects of each workshop were briefly described on each slide. We asked specific questions "How can we personalize the activity for participants? Is the creative expression element enough? What could be added?" during each discussion (Appendix E.1).

Throughout the presentation, any software or equipment the workshop ideas would use such as laser cutters or 3D printers, were shown and explained to the focus group with opportunities to ask questions publicly or anonymously so that everyone has an understanding on what workshops they would be deciding on.

Once we discussed the workshops, we had a form that the girls filled out where they ranked workshops from one to four, one being the best liked, and gave anonymous feedback on each idea (Appendix E.6). Based on the girls' selections and our discussions about what themes were important to them, we went forward with developing the most interesting idea from the focus group.

3.3.6 Expanding the Workshop to Develop a Multiple-Day Experience

Next, we considered the feedback the girls provided us with, and analyzed the data that was collected. The focus group's favorite workshop was developed further and their feedback was taken into consideration so that their opinions and voices were heard in this process. We continued to visit previous Camp Reach design principles that were successful and tried to implement them into our workshop. We used the previous Camp Reach design principles and new principles (generated in Obj 2?) as we moved from conceptual design to detailed design. The design principle we wanted to focus on the most while expanding our workshop was challenging the girls by providing hands-on experience and giving them a real-life engineering problem to solve. We wanted them to try to brainstorm solutions, build a prototype, and conduct

testing. This will make the girls work together and use their diverse knowledge, skills, and cultural differences to try and come up with a solution. These principles were included in our final product which has included an agenda with timing for the workshop. We also provided a materials list, the recommended space, and the learning outcomes.

3.3.7 Presenting the Activity and Get Feedback from a Focus Group

The third meeting held with the focus group included presenting a final workshop layout based on their ideas, and feedback we received. During the meeting, our participants were able to get an idea of what the workshop entailed and the flow of it through a meeting agenda style list. Along with that, they were given simple CAD instruction on TinkerCAD from the student investigators to simulate CAD instruction they could be receiving from Camp Reach.

To assess the results at the end of the workshop, discussed feedback out loud. Then, we utilized an anonymous survey on Google Surveys to give further opportunities for the students to reflect on what they liked and any improvements that could be made in terms of the workshop flow and teaching methods for the CAD lesson (Appendix F.4).

3.3.8 Redesigning Based on Feedback and Presenting the Final Solution

Based on the responses from the girls, we were able to gain feedback on our workshop agenda and our CAD lecture. With the agenda feedback, we were able to understand more closely if the timing of the workshop provided enough time for the girls to deliver a final product and if the provided structure promoted inclusivity. With the CAD lecture feedback, we were able to understand what resources middle school girls would need to learn a CAD program they may not be familiar with and if the teaching method we did in the focus group (a guided lesson on a simple part) was helpful in learning it.

At the end, our deliverables included an improved outline of the workshop, lists of needed materials, a recommended makerspace facility based on the final workshop chosen, and a list of learning outcomes.

4. Workshop Development

In this chapter we begin by presenting design principles for the workshop that emerged from our data gathering. We then present the pool of workshop ideas that we developed using the design principles and the specific selection criteria that we used to narrow the pool of ideas. After, we see how the final idea was expanded upon to become our final project.

4.1 Design Principles

Design principles are important to establish before the workshop development phase to ensure that important values and strategies are incorporated within the workshop. Through research, meeting with professors and our focus groups, we found common themes of what makes a workshop inclusive and educational. These similarities were emphasized as essential for success because of their ability to bring in students of diverse backgrounds and enhance STEM education experience. Through this, we have established a set of design principles that have guided us in our thinking for our final workshop design::

1. Ensure positive STEM relationships.
2. Use teamwork to promote inclusivity.
3. Provide an engaging, hands-on engineering experience in a project-based workshop.
4. Incorporate the engineering design process.

Each of these principles will be explained further in the sections that follow.

4.1.1 Ensure Positive STEM Relationships

Our first design principle is to ensure positive STEM relationships. We originally created this based on Camp Reach's own design principle to "Utilize a wide range of STEM role models and peer support" (Demetry & Sontgerath, 2020). Camp Reach originally understood the value of role models and peers as inspiration and support. This importance of peer-to-peer and adult-student relationships is shared within other programs and research-based planning tools (LaForce et al., 2019; Lyon et al., 2012; PEAR Institute, 2017). Specifically, in the Dimensions of Success planning tool, they indicate that having these positive relationships with both peers and adults are essential for socio-emotional development within a STEM program because having connections with those who are where you want to be and those within your own sphere are uplifting (PEAR Institute, 2017). Talking with our focus groups, these ideas are reiterated, but emphasized within the idea of how these relationships can impact inclusivity. In the first focus group meeting, a participant stated "I feel like a lot of people, women in particular, who are afraid to do what they want because a lot of men or authority figures they look up to put them down or tell them they can't do that" (Appendix D.4). This participant showed us how important it is for the role models in their lives to be positive and helpful because it matters in development and those ideas that start off young get carried throughout their careers. Middle school years are a critical time when girls are impressionable and aware of the judgments and opinions that authority figures, or mentors bestow on them. Because of this impact, we wanted to structure our workshop to allow for positive adult and peer role models because ensuring positive STEM

relationships will help fortify girls' confidence in STEM and validate that they are wanted and supported.

4.1.2 Use Teamwork to Promote Inclusion

Our second design principle is making sure our workshop was inclusive, however, we understand that there were limitations to the impact we could make. Regardless, inclusivity is essential to creating a welcoming environment for the diverse populations that could attend Camp Reach.

During our first focus group we had meaningful discussions about inclusion and race when we asked them about how different groups of people are treated in the world and the many issues within society. The girls were very aware about diversity and what goes on in the world like poverty, classism, colorism, racism, sexism, etcetera. One of our participants shared one of their classroom experiences in the chat during our Zoom focus group, "We were talking about racism and I said something and the teacher skipped over my chat and it made me feel like she doesnt think that's important. They weren't ready for my amazing and strong opinionated thoughts" (Appendix D.4). In the second focus group, a different participant expressed their concern with teamwork and the need for individual work because they were concerned about how they would be able to contribute to the project and grow their own skills. Both of these experiences are not isolated events because the lack of validation can steer students to want to work more individually in fear that their needs and ideas will not be heard. This made it really clear to us how aware middle school girls are of how they are perceived by others, and when someone is trying to avoid or deny their values and opinions. Specifically, we were able to learn that inclusion is more complicated than telling people of different backgrounds to work together. It is about how people interact with each other, and how freely URM feel they are able to express themselves within those interactions. To give girls that platform to share their opinions and ideas, and feel validated in doing so, our team realized that we need to be able to structure workshop teams in a way that promotes healthy overall teamwork and balances individual and teamwork technical aspects so that camp participants have multiple ways to get their voices out there.

Before working with the girls, we interviewed faculty members on ways to promote inclusivity. Shari Weaver who is the Director of a Teacher Prep Program and who had experience in K-12 education and Geo Interiano who is the Associate Director of Admissions for Diversity at WPI. After the interviews, our team got a better understanding of what makes an experience inclusive and the different resources WPI has to assist with that, which we used for our overall recommendations. From the guidance of our interviews and the focus groups we incorporated youth voice in our workshop planning (Appendix A.4).

4.1.3 Provide a Hands-on Engineering Experience in a Project-Based Workshop

Our third design principle is to provide an engaging, hands-on engineering experience in a project-based workshop. This was derived from one of Camp Reach's original design principles to "Provide an engineering experience for girls" (Demetry & Sontgerath, 2020). Camp

Reach focuses on engineering problem solving and design in STEM (Demetry & Sontgerath, 2020). We want to bring more of the project-based learning (PBL) aspect of it since PBL has been impactful on girls in conjunction with pursuing STEM futures and has led to better team behaviors and learning (Christensen & Knezek, 2017; Han et al., 2015). Sarah Jane Wodin-Schwartz agrees and recommended having the camp participants learn from their mistakes and reflect and iterate their ideas through different designs, which we ended up doing through integrating the engineering design process throughout the workshop. Wodin-Schwartz also emphasized that reflecting on one's mistakes is an important part of the learning process in a project-based setting which lead us to structuring the design portion so that students will look into multiple designs and work with their teams to determine which one is best fit (Appendix A.5). As we can see, PBL has potential to educate students and enhance their teamwork and critical thinking skills. Due to these benefits of PBL and Camp Reach's own design principle, we created this design principle to emphasize the importance of hands-on PBL, and ensure that we are always thinking about ways to enhance that PBL experience throughout the workshop development phases.

4.1.4 Incorporate the Engineering Design Process

Our fourth and final design principle was to incorporate the engineering design process. Incorporating the engineering design process in our workshop would allow the participants the opportunity to identify a problem, conduct research, construct a prototype and test it. We based this off of Camp Reach's design principle to "Challenge and support participants with multiple, hands-on engineering design experience" (Demetry & Sontgerath, 2020). By giving the students a way to go through the processes engineers use on a regular basis, it would not only give them a greater understanding of what engineering is, but how to think like one, and see themselves in that role. Shari Weaver expressed that in her interview when she said that being able to see yourself as an engineer is crucial to bringing girls into STEM since they develop that part of their identity as early as 7th grade (Appendix A.2). In addition to that, there was a disconnect evident in the first focus group meeting where girls knew engineering as a creation process, but not the intricacies such as what engineers do and the different fields. Many girls in the focus group described engineers as "people who just build things" and It can be challenging for girls to develop their STEM identity when they do not have a good grasp of what engineers do. As a result, we found that it was important to incorporate the engineering design process throughout the span of our workshop and adjusted our workshop agenda to do so. The engineering design process can be seen in Figure 3.

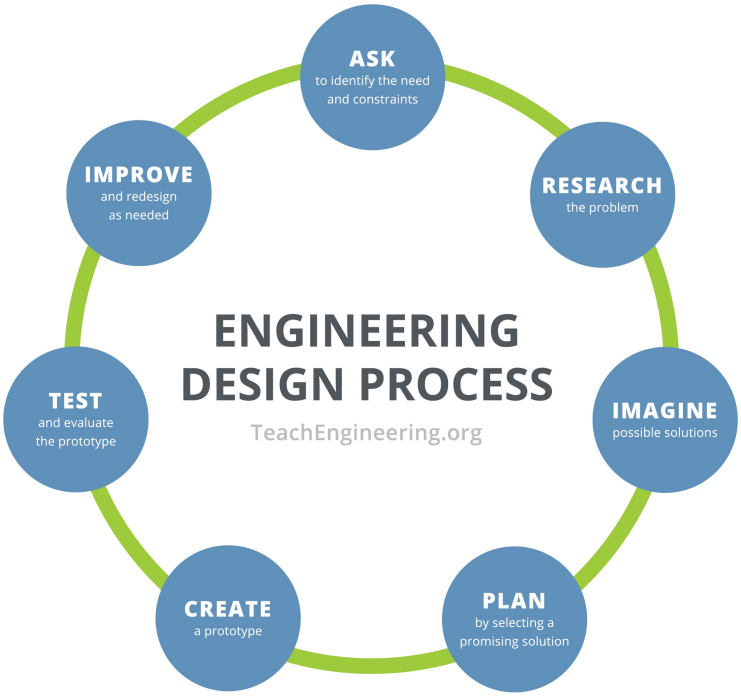

Figure 3: Engineering Design Process Diagram
Image Source: Engineering Design Process, TeachEngineering.Org, n.d.

4.2 Design Alternatives and Selection

In this section we present the large pool of workshop ideas that emerged from our initial brainstorming, which was guided by the design principles, interests of our co-designers, recommendations from interviewees and makerspace research. Next we explain and justify the selection criteria that we used to narrow down the pool of ideas, and the four specific ideas that we pitched to the focus group. The result culminated into a final workshop idea "Design Your Own Birdhouse" to be expanded on.

4.2.1 Makerspace and Technical Elements

Using the method described in the previous chapter, we were able to narrow down available spaces to use until we determined which ones we could recommend depending on the final workshop outline. We assessed five spaces at WPI and determined if the makerspace facility was appropriate for a workshop for this age group. Several were eliminated based on the maximum capacity of the space. This was true with most of the research labs, which made them not appropriate for the workshop. Others were eliminated because of the lack of variation of machines the girls could use in the workshop. The ECE 2010 Lab was eliminated for this reason. The ECE 2010 Lab contained computers but not other machineries such as a laser cutter or 3D printers.

We concluded that two makerspace facilities would be appropriate for this age group: Washburn and McDonough Makerspace and Fitzgerald Prototyping Lab. While we do have these two spaces, we took into consideration that we may have to split up the girls during the workshop. From interviews and research, it was found that the max capacity for Higgins Labs was 40 people. With this in mind, we determined that if the McDonough Makerspace and Fitzgerald Prototyping Lab were going to be used, that the CAD would be completed in Higgins Lab and the prototyping would be completed inMcDonough Makerspace and Fitzgerald Prototyping Lab.

Washburn is a machine shop that has 12 computers, a Universal Laser Systems VLS60 Laser Cutter, a Makerbot Replicator 2X, MiniMills, and SL10s. This machine shop has the type of machines the team wanted to include in the workshop which would provide the girls with a sophisticated engineering experience. Additionally, there was also a safety training presentation that seemed suitable for 8th grade girls, so that they were familiar with the machines before using them. This was not a determining factor for potentially using the space but it was something the team wanted to know if we did decide to go with this space in the future.

The McDonough Makerspace and Fitzgerald Prototyping Lab is a makerspace and prototyping lab located in the Foisie Innovation Studio at WPI. It has 16 workbenches that have four stools per bench, 3D printers, a laser cutter and a waterjet. This space was found to be ideal because of the laser cutter and workbenches where the girls could assemble their birdhouses. In an interview with Adam Sears, the Director of Foisie Innovation Studio Technical Operations, we were suggested to not have lectures within this location because the space is not meant for lectures. (Appendix B.2) Instead, he suggested that we use a computer lab such as Higgins Labs to lecture and then to use the makerspace as a place to assemble pieces.

4.2.2 Initial Brainstorming for Workshop

Our brainstorming was influenced by the following suggestions given by WPI faculty and staff members as well as the focus group:

- **Making use of backward design.** Sarah Wodin-Schwartz suggested this to our team to ensure that we are obtaining the outcomes that we would like our workshop to achieve, and structuring the workshop around that outcome. Notes from Sarah Wodin-Schwartz interview can be found in Appendix A.5.
- **Using physical interaction and demonstrations.** Sarah Wodin-Schwartz also suggested this because the use of physical interactions and demonstrations allows for students to connect to the material better.
- **Incorporating hands-on prototyping.** Erica Stults suggested incorporating hands-on prototyping into our workshop during our interview with her. She noted that this idea could elevate a basic workshop idea to include a technical skill, learning outcome, and enhance girls' understanding of engineering. Notes from Erica Stults interview can be found in Appendix A.3.

- **Include topics that the focus group was passionate about.** In order to understand what middle school girls like, we asked them about topics they were passionate about. The girls in our focus group wanted to do work that mattered and that could help the community in any way. They were passionate about issues that revolved around mental health, inequality, the environment, and animals to name a few. Focus group 1 outcomes can be found in Appendix D.4.

From our interviews and focus group 1, we came up with the following ideas for workshops as seen in Table 1.

Table 1: Table of Workshop Brainstorm Ideas

Workshop Idea	**Topic**	**Machinery Needed**
Build a flashlight.	Electrical Engineering	3D Printer
Create a moving mechanism using 3D printed gears and parts.	Engineering Combined With a Mechanism Problem Solution	3D Printer or Laser Cutter
Creating a functional planter to grow your own food.	Environment, Helping the Planet	3D Printer
Creating a birdhouse.	Environment, Animals	3D Printer or Laser Cutter
Designing a prototype for a multipurpose tool.	Helpful in Daily Life	Laser Cutter
Creating a hot dog or food cooker.	Making Your Own Food	Laser Cutter
Egg Drop	Newton’s Laws, Basic Engineering Concepts	Laser Cutter
Design a boat that will float with one person in it using only cardboard and duct tape.	Buoyancy and Center of Gravity	Would use CAD to design but cardboard to make.
Design your own version of a fidget spinner or fidget cube.	Mental Health Awareness	3D Printer or Laser Cutter
Design your own board game.	Incorporate the Team's Interests Though a Theme	3D Printer or Laser Cutter
Create your own sport.	Physical Activity	3D Printer or Laser Cutter

4.2.3 Four Workshop Ideas

When deciding the four workshops to present to the co-designers in our focus group, we looked deeper into what is important to the students, how we can incorporate a makerspace, and what is feasible to do in a workshop. Based on those factors, we created the following criteria to narrow down our initial pool of ideas:

- **Feasibility within four days:** Camp Reach is only a two week program and has many different activities and workshops planned throughout the day, so our workshop could only last within that time for at most three and a half hours each day.
- **Compatibility with makerspaces:** This element typically included being able to design on CAD and create a part of the project in either the 3D printers or the laser cutters. In our final four options, we used ideas that could use either machine, but we were told by Erica Stults that using 3D printers could be disengaging since 3D printed parts are done by lab staff, so it is primarily a watching experience, in comparison to laser cutting that is a more hands-on experience.
- **Creative aspect incorporation:** We found that students really valued creative expression, so the creative aspect incorporation criterion was developed. (Appendix D.4) The co-designers were really interested in topics like art, writing, and reading. Art made them feel confident, and inspired confidence to work on projects and innovate. To make our workshop more engaging, we realized that this was important and chose workshop ideas that would give more room for creative expression and elements.
- **Real world problem solving or application:** This was important to our middle school girl co-designers because they had an affinity to do work that helps others. As a result, giving them projects that incorporate engineering and real world problem solving or application could inspire them to want to learn more. We included this criterion and it helped us narrow ideas down to those that have a broader application than just math and science.
- **Age-appropriate curriculum:** This was to ensure that the right amount of challenge is given to the girls and that the learning curve for the new concepts are not overwhelming. In our interview with Shari Weaver we were recommended to gauge the girl's interests and education to understand what they know so in focus group one (in Appendix D.4) We talked about their interests, some of those being physics, coding, and nursing. We were also advised by Erica Stults (Appendix A.3) that CAD has a steep learning curve, and may take a long time to learn it, given that most middle school students will come into the program not knowing about it. To cope with this, we chose projects that we could either simplify the parts made in the project or have pre-designed CAD sketches for students to edit.

Using these criteria, we decided on the birdhouse, planter, board game and fidget spinner ideas as the four workshop ideas to present in our second focus group meeting with our co-designers. The pitches can be found in Appendix E.2. All four pitches were compatible with Washburn Shops, and/or The McDonough Makerspace and Fitzgerald Prototype Lab in Foisie,

and were capable of being completed in four days. The workshop pitches possessed an age-appropriate curriculum that also allowed for an expansion of knowledge into technical aspects such as CAD and 3D printer or laser cutting. The real world problem or applications for each pitch were the following:

- **Birdhouse:** For the birdhouse idea we focused on ways birdhouses play a role in promoting a healthy backyard ecosystem in residential areas, and how they can be beneficial to the environment.
- **Planter:** For the planter idea, we wanted participants to learn the importance of growing your own food and being in control over the things that end up on your plate.
- **Board Game:** For the board game we wanted to incorporate their own interests and come up with a theme to design a board game
- **Fidget Spinner:** For the fidget spinner idea, we wanted the participants to learn about mental health and how a fidget spinner can help people dealing with anxiety and stress.

4.2.4 Selection of Final Workshop Idea

During the second meeting of the focus group, we presented the four workshop ideas described above. Each "pitch" included creative aspect, learning outcome, technical skill and general flow of events. We presented the four pitches using the same format for each workshop. The format included what participants would learn during the workshop, ways they would design that idea using CAD, how they would create the pieces of that idea using 3D printers and/or laser cutters, how they would assemble their design using various tools, and lastly how they would express themselves during each workshop idea. The pitches can be found in Appendix E.2.

We had participants judge the workshop options by taking into consideration the inclusivity of each idea, collaboration, personalization, and safety. We asked them the following questions for each idea:

- **Inclusivity:** What makes a space inclusive or welcoming to you?
- **Collaboration:** How would you split up the roles when working on your CAD or projects?
- **Personalize:** How can we personalize the activity for participants?
- **Safety:** What safety aspects would you be concerned about when learning about machinery?

For the birdhouse idea, the girls suggested having specific roles for each participant in the group, to make the idea more inclusive. They recommended making time in groups to share opinions so nobody would feel left out. They also really liked the idea of creating discussion questions, which could help someone who is shy express their opinion. Next for collaboration, they wanted to work both in groups and individually. They recommended working in teams during the CAD portion and working individually during the personalization portion. They suggested painting and coloring to personalize the design. For safety, they wanted reference sheets on how to use laser cutters so everyone can stay safe. Lastly, they suggested having a choice of material like a bird feeder or a birdbath as options. One of the focus group participants

stated the following about the birdhouse workshop idea: “I love idea 1. I think that it gives a chance for people to express themselves and learn how to work in groups”.

For the planter idea, they suggested providing a variety of seeds to plant so everyone can feel included. Additionally, one of the focus group participants stated the following about the planter idea: “I love this idea because you are learning how privileged you are and learn about a life skill" (Appendix E.4). For collaboration, they recommended using CAD separately but work together when doing research. They wanted to personalize by using markers or stickers to decorate their planters. For safety, they suggested reference sheets or video demonstrations on how CAD works Lastly, their only concern was that this idea might not be as fun as the other ideas.

For the fidget spinner idea, the focus group participants suggested having options to choose from, for example stress cubes, stress balls, or origami to make everyone feel included. For collaboration they recommended working individually, and they preferred having a CAD and laser cutting demonstrations as a safety aspect. They also suggested painting for personalization. Additional suggestions include teaching the benefits of fidget spinners and how they can be useful for stress and anxiety and their only concern was this idea not being as interesting because fidget spinners are not as trendy anymore. One of the participants stated “A way I would improve this idea is allowing the students to read about how fidget items help with people who are very fidgety or ones that need it. Once they are filled with that knowledge, I think I would want to make it a lot more, especially if they knew it would help others in tough times” (Appendix E.4).

Lastly for the board game idea, they suggested dividing up the board into different pieces for the participants to work on, so everyone feels included. They thought working in teams of two to six people was a great option. For safety, they recommended using videos or reference sheets on how to use laser cutters. For personalization, they wanted each team to decide on their own theme for their board game. Additional suggestions include making time for each other's prototype presentation and have each team play each other's board game. Their only concern was timing and how this idea might take longer than three days to accomplish. A participant said “I like this because it will provide for a great hands-on experience. It might take a long time though so maybe make it a small tabletop game” (Appendix E.4).

At the end, we had a form that the girls filled out where they ranked workshops from one to four, one being the best liked, and gave anonymous feedback on each idea (Appendix E.6). Birdhouse came in first, the planter also came in first, the board game in third and the fidget spinner came in fourth. After considering our co-designers feedback, as a team we decided on the birdhouse idea. The birdhouse workshop will provide the girls with the opportunity to construct shelter for the birds around their neighborhood using the engineering design process. The girls will learn the benefits of a birdhouse and ways they help the environment. Additionally the girls will be able to strengthen their teamwork and listening skills and be able to learn from each other's diverse ideas. They will design the pieces of the house in a team using CAD and in

the end they will be able to personalize their own designs individually and be able to express themselves in their own creative way.

4.3 Final Workshop: "Design Your Own Birdhouse"

Once the birdhouse idea was decided, we worked on developing our final workshop by expanding that into a three-four day event. The breakdown of the days are: "Introduction with Research, Design and Prototyping", "CAD and Machinery", and "Assembly and Reflection/Discussion." Camp Reach participants will go through the engineering design process throughout the duration of the workshop to create a birdhouse. This will be important to understand what engineers do and put themselves in that role. When deciding the flow of the events for the final workshop, two aspects played a large role in guiding it: maintaining engagement throughout the project and the learning curve for CAD.

4.3.1 Maintain Engagement

We found that maintaining engagement throughout the workshop was important to get girls excited about learning STEM and the new content from our workshop. When making our final workshop design we used the following considerations from our interviews. Sarah Jane Wodin-Schwartz recommended that we keep the students busy and include breaks (Appendix A5). There will likely be students who finish early with different parts of the assignment, or may feel overworked. To get both sides of the spectrum consistently engaged, adding more activities for students who finish quicker will help to increase their own interest, and taking breaks for students who may be struggling is just as important so they could take a step back and start again with a fresher perspective.

During the machinery part of the workshop, we were also recommended by Erica Stults to not focus too much on having students watch the process since it could be repetitive, so in the workshop, we adjusted it so that the camp participants would have the chance to learn how to use the machines and see some pieces start getting cut out, but the majority will be done outside of workshop hours (Appendix A.5).

When we discussed our workshop plans at the last focus group meeting, we found that the co-designers generally enjoyed the design of the workshop, but wanted some more time for the creative portion at the end where camp participants will get to paint a birdhouse. To account for that, we adjusted the timing so on the final day of the workshop, teams can take as much or little time to work on their birdhouse assembly, then spend the rest of the time with the reflection/discussion while painting (Appendix F.2).

4.3.2 Learning Curve for CAD

Out of each part of the workshop, the most difficult portion will be the CAD learning curve since it is a sophisticated process that many don't start at during middle school and may take more time than expected. Specifically, Erica Stults, one of our interviewees expressed concern that CAD would take up the whole workshop time since it was in-depth and complex.

Sarah Jane Wodin-Schwartz agreed, recommending that we multiply our learning time by at least two and/or had a test run with students (Appendix A5). Realizing this could be a problem since a CAD lesson for the whole duration of the workshop would not be engaging, we solved this issue in two ways. First, the workshop itself is designed to have simpler parts with a dedicated lesson and some individual work with team and staff support as needed. Additionally, we decided to use Stults' recommendation to test with our focus group since a lot of us in the project group already had CAD experience, so we were better able to gauge how much time middle school girls would need to learn it.

To teach CAD, we initially did not have much to start with, so we used some advice from our interviewees from the makerspace research. James Loiselle gave some suggestions for teaching students such as step-by-step or with tutorials (Appendix B.3). This suggestion was used because we learned that CAD could be harder to learn and having different methods to teach would make it more accessible and inclusive. Additionally, Adam Sears recommended we use TinkerCAD for beginners (Appendix B.2). Looking more into TinkerCAD, we realized it was an effective way to start teaching students CAD because the user interface was easier to grasp (in comparison to programs like SolidWORKS and AutoCAD), and it was free and available to most devices. This was important for a 30-45 minute lesson within a 1.5 hour focus group meeting. So, we ended up using all of these suggestions to grasp how the CAD worked.

During the third focus group we had an "Intro to CAD" lesson that started off with a tutorial of the basics from TinkerCAD led by one of our group members. The lesson then followed with a step-by-step tutorial to build one of the parts of the birdhouse: a rectangular piece with a hole in it. Initially, the CAD lesson was meant to take 30-45 minutes for the step-by-step portion to create a block with a hole in it, but after testing it in our focus group, we found that it took only half the time needed. During this time, we learned that having those multiple ways to learn such as step-by-step instructions, and reference sheets was actually incredibly effective for the girls. The girls were able to grasp the original piece, and we were able to expand the lesson impromptu to teach girls how to make different objects like beads and use workplanes. Some of the feedback we got was "I loved this so much and I will be making things a lot! Thank you for doing this class. I had so much fun and I am inspired to become an engineer to pursue creative hands-on stuff!" and "I went into it like I didn't know how to work tinker cad and I wasn't confused at all" (Appendix F.2). Based on what we got from this, we realized that SolidWorks with more effective teaching (rather than one of the group members) would be feasible for the girls since they were able to understand the program better than anticipated. It is important to note though that SolidWorks itself was not tested with the students and may need different resources such as more detailed reference sheets that are very visual and videos.

4.3.3 Workshop Agenda

Our workshop agenda for "Design Your Own Birdhouse," spans across four days for approximately 3.5 hours per day. Camp participants will be going through the engineering design process in teams of 2-3 to design a birdhouse on CAD, then laser cut the pieces at the

makerspaces. Here is an overview breakdown of the workshop days. Please refer to Appendix G.1 for more details.

1. **“Introduction with Research, Design and Prototyping”**: Students will be working in teams to go through the beginning of the engineering design process: research, design and prototype. Teams will first generate questions for research, then look for answers using the Internet in order to learn about the values of birdhouses and what is needed to create them. Then, teams will use their research to design multiple types of birdhouses they could possibly make. After, they will prototype their chosen design. The prototyping phase will include a hands-on component that focuses on measuring parts and creating realistic models to get students prepared for the CAD on SolidWorks.
2. **“Introduction to CAD”**: This day will be a smaller workshop segment designed to get students first situated with CAD. Students will be working with staff to set up accounts to save their projects, then start with an introductory lesson that first gets them familiar with SolidWorks. This was added so that students will not be overwhelmed with new CAD information on one day.
3. **“CAD and Machinery”**: Students will be working individually to CAD pieces that were designed by the group previously. Then, they will come together to cut them out using a laser-cutter. This will bring the balance of teamwork and individual skill development. On this day, they will be given a CAD lecture and support from their team and staff throughout the CAD process. In the middle of that, they will also have a chance to learn about and view the makerspace and the laser cutter that their parts will be cut out on to learn about the manufacturing side of Mechanical Engineering. Students will have a chance to get machine training, but staff will primarily play a role in cutting out the parts.
4. **“Assembly and Reflection/Discussion”**: By this day, students will receive the parts that were cut out for the birdhouse and will work with staff and their teams to construct their birdhouses. Following, there will be a chance for teams to reflect and discuss their progress, and work. During this time, students will be provided art supplies to decorate their birdhouses.

By the end, students will learn about the design and manufacturing fields of Mechanical Engineering, how to develop a project through phases of ideation, prototyping and completion using the engineering design process, how to translate a prototype to CAD on SolidWorks, and communication and listening skills by working in teams.

4.3.4 Workshop Materials List

The materials list was taken from what was needed from the birdhouse and divided into three types: prototyping materials, final product materials and creativity materials. The breakdown of the list is below.

- **Prototyping Materials**: Cardboard, foam, measuring tape, permanent markers, box cutter/exacto knife

- **Final Product Materials**: Baltic Birch Plywood, wood glue, safety glasses, masks, dowels.
- **Creativity Materials**: markers, latex-based or water/outdoor proof paint, sharpies, brushes, gloves, aprons

We decided the following WPI spaces for the technical aspects of the workshop. For the CAD lesson, it is decided to use the Higgins Computer Laboratory for its capacity and machines that have SolidWorks already downloaded. The room also contains a projector that would be helpful for step-by-step instructions to guide students through the lesson on the second day. As for the machinery portion, we decided to use Washburn Shops, and The McDonough Makerspace and adjacent Fitzgerald Prototype Lab in Foisie. Both makerspaces contain laser cutters and have the capacity to either hold all the students or in groups. Additionally, we evaluated that these spaces were feasible from past program experiences at WPI and safe with training provided by the facility. It is important to note though that Washburn would be primarily used for laser cutting while the makerspace in Foisie would be good for both laser cutting and assembly.

4.3.5 Workshop Learning Outcomes

After participating in our workshop, we anticipate future Camp Reach participants will gain more knowledge in engineering, technical skills and teamwork. Here are the learning outcomes we found from our workshop agenda:

- **Learn about the design and manufacturing fields of Mechanical Engineering.** They will design the pieces using CAD to build the walls of the birdhouses and use machinery to manufacture the parts.
- **Learn how to develop a project through phases of ideation, prototyping and completion using the engineering design process.** Our workshop will bring students through the engineering design process by developing a birdhouse through the process of research, design, prototyping, manufacturing, and assembly.
- **Learn how to translate a prototype to CAD on SolidWorks.** They will get a chance to work in a team by designing the pieces onto CAD then further develop technical skills by getting them laser cut showing how designs get translated into tangible objects.
- **Learn communication and listening skills by working in teams.** They will get a chance to work together in a team facilitating idea generation and creativity and it lets participants practice their listening and communication skills.

4.3.6 Workshop Recommendations

From our interview with Shari Weaver, we learned that one way of helping to improve inclusion is teaching content in multiple ways because students learn in different ways which in turn helps students feel represented (Appendix A.2). When teaching the CAD lessons to the camp participants we recommend using a combination of the following:

1. **Create a visual handout with step by step CAD procedure or a handout that helps you learn the basic CAD functions.** From focus group 2 the co-designers came up with

the idea to have a visual handout of the CAD project that they can use to guide them while working on their own designs. (Appendix E.3)

2. **Have a staff member teach the lesson step by step on a projector in front of the computer lab while other staff walk around to answer questions.** In focus group 2 we presented this idea and the co-designers agreed. However, they still would like to have a reference sheet with this lecture format. (Appendix E.3)
3. **Add a video component to teaching CAD step by step.** In focus group 3, one of our co-designers recommended this so that the camp participants are able to go at their own pace. (Appendix F.2)

Overall, we recommend implementing at least two of these methods of teaching CAD. It is important to have multiple teaching methods that way the camp participants' learning styles are all accounted for. Accounting for these different learning styles will help promote inclusion by making sure that every participant's learning styles are represented.

Throughout this process we came across more general workshop recommendations that can be implemented throughout the duration of the workshop. These recommendations are the following:

1. **Teams should consist of randomly assigned groups of 2-3.** Originally we considered grouping teams by hometowns so that the birds from the area would be the same. However, we want to avoid homogenous thinking that could come from students coming from the same area and/or background. Randomly assigned groups will also help create an inclusive nature so camp participants will not feel left out.
2. **When introducing the project, incorporate the engineering design process.** This step will allow camp participants to understand the steps of the workshop as well make the connection that they are using the engineering design process.
3. **When teams are first put into groups, have a set of questions to discuss to create team goals and rules, as well as prepare an icebreaker.** This will help the team work more effectively and allow for the girls to feel more comfortable within their teams. This was presented during focus group 3 and we did not receive negative feedback from the co-designers. This will also help promote inclusion because it will allow the girls to feel more comfortable voicing their opinions if they have a system or rules set that allow for all voices to be heard.
4. **Have the camp participants create birdhouse CAD pieces that have rectangular cutouts so that the walls will fit together as puzzle pieces and can be glued together.** This will allow for the birdhouse to be structurally sound, while also challenging the girls with CAD.

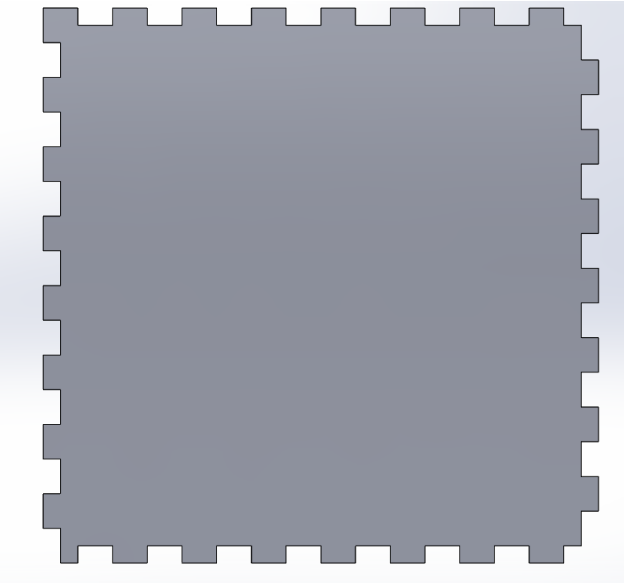

Figure 4: Example of One Wall of the Birdhouse CAD Piece

5. **Plan additional activities in case the camp participants finish early.** Erica Stults recommended that we have a plan for possible timing issues such as additional activities (Appendix A.3). We have recommended specific times for each step of the workshop on the workshop agenda, however, some camp participants may grasp CAD quicker or slower which could result in some participants finishing early.
6. **If parts are not completed being laser cut, plan to take a day break between Day 3 and Day 4 to complete cutting the parts.** This will allow for parts to be cut by staff in a way that is not rushed. In the Table 2 below are time estimates and laser cut setting suggestions to guide cutting.

Table 2: Time Estimates and Settings for Laser Cut Parts

Material	**Laser Cutter Power Setting**	**Laser Cutter Passes Setting**	**Estimated Time to Cut 1 Wall**	**Estimated Time to Cut 6 Walls**	**Estimated Time to Cut 30 Birdhouses**
⅛ in Piece of Baltic Birch Plywood	35	3	6 minutes and 11 seconds	37 minutes and 6 seconds	Roughly take 19 hours
1/4 in Piece of Baltic Birch Plywood	50	4	8 minutes and 18 seconds	49 minutes and 48 seconds	Roughly take 25 hours

7. **Use inclusive language in guides and explanations that is recognizable or taught to all camp participants.** Shari Weaver shared with us the importance of using inclusive language such as creating broad examples or explaining in multiple ways so that concepts are taught in a context that is recognizable to everyone (Appendix A.2). This allows participants who come from different backgrounds where English may not be their first language to understand content the same way a participant whose first language is English would.

Maintaining engagement, managing the learning curve of CAD, providing a workshop agenda, material list, and learning outcomes all came from the extensive research and the focus group studies. Applying the aforementioned recommendations paired with our final deliverables will allow for the workshop to run more smoothly and be inclusive for participants from all backgrounds. This will allow for Camp Reach to have a new hand-on engineering workshop that promotes an inclusive environment for camp participants.

5. Conclusion and Recommendations

In this chapter we will provide our project overview, a summary of our findings, our design principles, describe our workshop deliverables and provide recommendations. We researched other STEM programs, met with faculty WPI members, and held three focus groups to help us complete a workshop plan for Camp Reach.

5.1 Summary of Contributions

A key contribution of this project is a new set of design principles, which were a crucial component when designing our workshop. Our design principles are the following:

1. ***Ensure positive STEM relationships***: We wanted the participants of our workshop to establish positive relationships with both their peers and adults. These types of relationships were shown to be essential in making connections with others and for impacting inclusivity.
2. ***Make our workshop inclusive***: We will do so by creating a welcoming environment for diverse populations. As a team we realized how important inclusive language was and that the structure of our workshop needed to promote healthy teamwork. With the help of our focus group we decided it was important to balance both individual and teamwork for participants, to help include all voices.
3. ***Provide an engaging, hands-on engineering experience in a project-based workshop***: Project-based learning has been impactful on girls' decisions to pursue a STEM career. After interviewing Sarah Jane Wodin-Schwartz we realized having the camp participants learn from their mistakes and reflect and iterate their ideas through different designs was also very important.
4. ***Incorporate the engineering design process***: This would allow the participants the opportunity to identify a problem, conduct research, construct a prototype and test it. This would give them a greater understanding of what engineering is, how to think like an engineer, and see themselves in that role. For girls especially it can be challenging to develop STEM identities and it's important to have them see what engineers actually do.

Through looking into our design principles and going through the phases of ideation, selection and development, we were able to meet our original objective of creating a sophisticated workshop experience for Camp Reach. Our workshop, "Design Your Own Birdhouse," will span four days to include a day for research, design and prototyping, introduction to CAD, CAD and machinery, and assembly and reflection. Throughout the workshop, participants will gain new technical skills, learn collaboration skills and use their creativity. To complete the workshop we recommend the Higgins Computer Lab for CAD instruction, Foisie and Washburn for laser cutters, and Foisie for assembly. By the end, students will learn about design and manufacturing fields of Mechanical Engineering, how to develop a project through phases of ideation, prototyping and completion using the engineering design

process, how to translate a prototype to CAD on SolidWorks, and communication and listening skills by working in teams.

5.2 Recommendations

Throughout the process of designing the workshop, we have developed recommendations that are in addition to the workshop agenda, makerspace, material list, and learning outcomes. We provide the following recommendations to the Office of Pre-Collegiate Outreach Programs.

1. **Test the timing of the workshop.** Due to the COVID-19 pandemic, the team was unable to have a run through of the workshop from start to finish. To ensure accurate timing in CAD and the makerspace, a practice run of the workshop would be recommended. Ideally, this would be done with at least one team of participants. This way, certain time adjustments to the workshop agenda can be made before Camp Reach is in session. Also, there is a chance that some teams may struggle to complete their CAD because of learning difficulty or technical issues. We recommend having a premade design for a birdhouse for students to work on, so that they will still be able to complete the project in the given time.
2. **Use pre- and post- surveys to assess success of the workshop and identify areas for improvement.** In order to see the impact of the workshop, we recommend including two anonymous surveys for the camp participants to take: one before and one after the workshop. Questions could include a scale of 1-10 of how well the participants understand the engineering process, how comfortable they feel prototyping, if they feel that their opinion has been valued, and more. These questions could be answered before and after the workshop to gage if the participants felt as if they learned more about engineering from the workshop, and if they felt as if they were supported and that their voices were heard throughout the workshop. Using a before and after survey ranking system will allow for quantifiable data that will help with inclusion practices going forward as well as understanding how the workshop teaches engineering.
3. **Increase attention to diversity and inclusion in staff training.** No single workshop will make the whole program inclusive; therefore, our team recommends a way we can improve inclusivity in our workshop even just a little bit, is through staff training. According to our sponsor, Suzanne Sontgerath, Camp Reach used to have a day and a half for staff “diversity” training. The training focused more on how to be good role models for the participants, rather than inclusion. As we said earlier, our team wants to ensure positive STEM relationships between participants and staff members because it was shown to be beneficial to the inclusion and engagement of URM participants. We want them to feel included and establish relationships that will last throughout middle school and high school. During our focus group, our co-designers expressed their frustration with feeling excluded and being bullied by classmates and staff because of their gender and color of their skin. They felt like their ideas were not acknowledged, their opinions were belittled and felt hurt and not wanted. One of the girls said that a way

to help solve these problems was by “Educating people about them because they might not know what the problem is because it's too hard of a topic to talk about" (Appendix D3). Another way to iterate what this participant said is that people tend to not talk about racism and discrimination because conversations like these can be uncomfortable, especially for white people. Staff need to feel comfortable talking about difficult topics like race because people’s identities impact how they experience the world. Being able to acknowledge that and address needs that come with those unique experiences is essential for inclusion and positive engagement.

This is why our team recommends Camp Reach staff members and leaders to be trained and educated more on diversity, and learn how to address bias. Specific inclusion training for staff members can be a good way to address biases, it can be especially helpful to teach different ways to identify and deconstruct biases we have on our own without knowing, before participating as leaders at Camp Reach. In addition, we also suggest a more in-depth training to understand what different racial, gender, sexuality and ability groups need because understanding the intersection of people’s identities is another aspect of inclusion. After talking to Geo Interio, our team recommends talking to the Inclusion Office for more information on anti-racism training and safe zones.

Overall, including these recommendations will allow for further development of the workshop and better inclusion practices within Camp Reach. Camp Reach is a place for middle school girls to develop a passion for STEM and a place to help increase the amount of women in STEM. We hope that through our workshop and recommendations that Camp Reach can implement a staff training that will allow for a better prepared staff to uplift URMs and see that all camp participants have the equal opportunity to develop a passion for STEM.

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Appendix A: Interview Notes

A.1: Interview Notes with Suzanne Sontgerath

Minutes for Interview with Suzanne Sontgerath (September 21, 2020)

Attendees: Suzanne Sontgerath and team members Meghan Hendry, Aleksia Karapanco, Marisa Maltais, A. Ungerer.

Points Discussed:

1. **Experience**: What kind of outreach have you done to improve inclusion in pre-collegiate programs as director? What methods have you used to promote diversity and inclusion in the past? Have they worked?
    a. As a director, Sontgerath has worked to improve inclusion by looking at how we can first get diverse populations which is what she called the first step before changing the curriculums to promote inclusion.
    b. The first method used was communication. The Office of Pre-Collegiate Programs partnered with schools and local community-based organizations so that those who do not know to search for those opportunities have a chance to participate as well.
    c. The other method used was explaining and providing financial assistance because that may be a barrier or a deterrent for tuition-based programs.
    d. Using both of these methods strategically is important to gain exposure, and get diverse populations to apply to WPI Pre-Collegiate programs.
2. **Advertising**: How did WPI promote Camp Reach in Worcester? Were there any attempts to address underserved communities? If so, how did WPI go about that?
    a. Mentioned in Experience, one of the ways Camp Reach is advertised is through schools and local community-based organizations to specifically reach underserved communities. The other ways include the WPI website, word-of-mouth and a general program brochure.
    b. Some of the weaknesses that arise from these methods are the following:
        i. WPI is not associated with Worcester Public Schools and oftentimes, the brochures do not get to the hands of students because schools do not want to advertise tuition-based programs.
        ii. There has been success with directly finding individual students through school career planning programs, but those selected are predisposed to pursuing engineering, so we may not reach underserved students.
        iii. The brochures and fliers do not have multiple languages. Parents from diverse backgrounds may be less likely to allow their children to stay in residential programs if they do not understand it’s logistics or do not have a personal connection.

3. **Financial aid:** How does WPI appeal to communities that find Camp Reach unaffordable? Is there any student that could not attend because of program tuition?
    a. Also mentioned in Experience, financial aid is a crucial part of accessibility for Camp Reach which is a tuition-based program, and WPI has been able to give money to any student who wanted to attend, but wasn't able to afford it.
    b. One of the challenges in the financial aid is how to reach the same level of commitment for those who get full scholarships in comparison to those who pay. There have been instances where students do not follow through with joining the program and being limited in attendees, it takes away a spot from another student.
4. **WPI**: How does the school look to promote diversity and what has been done to do so?
    a. With the first female president at WPI, Laurie Leshin, there has been lots of success in bringing women to campus.
    b. There has also been an increase in programs that serve minority groups so that the campus has both student organizations and staff-lead offices because it was recognized that minority populations may need different resources to thrive.
    c. The diversity issue has improved, but still needs to get better because WPI's challenges are part of a bigger issue of diversity in STEM because of socioeconomic barriers that prevent women of color and underserved populations from exposure and success in STEM.
    d. WPI admissions has considered the intersection of identities and available resources to bring diverse populations onto the college campus, but this is a problem that goes beyond the college level and the root of the problems lies earlier on.
5. **Staff**: Do Camp Reach employees have diversity training? What does that consist of? What is the typical racial breakdown of the staff? Is diversity kept in mind when hiring.
    a. The breakdown of the staff mostly included people from the Office of Pre-Collegiate Programs that identify as white and/or Caucasian. Below are how the staff are broken down by categories and the challenges:
        i. Program staff: Camp Reach has faced challenges in recruiting teachers of color, and that is reflected in the applicant pool.
        ii. Residential staff: There is an attempt to diversify as much as possible because there is a big pool, and that progress is being made.
        iii. Teaching staff: They usually come from program alumni. White or caucasian girls tended to return to the program as staff in comparison to girls of color, so there is a disconnect in future engagement.
    b. Camp Reach used to have a day and a half for training from a grant, but now has a one-day training that focuses on role-modeling with a touch about diversity.
        i. It has been suggested that implicit bias training could be helpful to teach staff members how to identify and deconstruct their own biases before participating as leaders at Camp Reach.

A.2: Interview Notes with Shari Weaver

Minutes for Interview with Shari Weaver (October 5, 2020)

Attendees: Shari Weaver and team members Meghan Hendry, Aleksia Karapanco, Marisa Maltais, A. Ungerer.

Points Discussed:

1. **Experience**: What is your experience with K-12 STEM education?
    a. Weaver graduated as a Biology major and has spent a lot of her career in the STEM field with high school as a science teacher for 11 years and a technology teacher for 2 years and well as being a staff member of a robotics team.
    b. At WPI, Weaver used to be the K-12 Outreach Coordinator and her first experience was observing Camp Reach so she is familiar with the program.
2. **Working with Girls**: What have you inferred about girls' views about engineering in middle school? How has that changed during your career?
    a. Girls understand the broad fields of STEM such as engineering, biology, chemistry and physics better than in the past, but do not know about the specific fields and practices such as electrical or mechanical engineering.
    b. As early as 7th grade, girls start to identify as a STEM person, so intentional exposure needs to be used in order for girls to see and understand themselves to be scientists and engineers.
3. **Developing Curriculum**: How do we determine what is age-appropriate STEM curriculum?
    a. We were given some resources to look into such as Massachusetts state education standards, NASA sources and Teach Engineering to get a baseline of what middle school girls are learning and some themes that could be interesting.
4. **Inclusion**: What experience have you had bringing inclusion into the classroom and how effective has it been? What about in regards to English learners who come from immigrant populations?
    a. In diverse urban areas, where Weaver taught in the past, there were many issues that students faced such as school segregation or incarceration. To address that, we look into different strategies:
        i. Multiple intelligences: It is important to understand that there are different ways of teaching different students. We were recommended to look into the strategy of "differentiated instruction" and philosophy of "universal design for learning".
        ii. Resources and support for English-language learners (ELL): Students with immigrant parents or from other countries may not be proficient in English. To include students, it's important to be able to recognize

academic, content-specific and everyday language and teach it in context so that they can learn and grow into it.

iii. Multiple modes of representation: Where language may not be enough to teach, it is useful to have a physical way to describe or connect concepts.

5. **Training**: What diversity and inclusion training have you experienced? What have you recommended to staff?
    a. Weaver works with WPI students at the STEM education center and has delivered training on diversity and inclusion in the context of STEM. This training has been extended to having younger students learn about it.
    b. We were recommended to look into Sanford Inspire or MIT Edx course for more information on diversity training that transition from identifying and deconstructing implicit biases to valuing cultures and turning that into being educators of change.

A.3: Interview Notes Erica Stults

Minutes for Interview with Erica Stults (November 05, 2020)

Attendees: Erica Stults and team members Aleksia Karapanco and Meghan Hendry.

Points Discussed:

1. **Experience:** What's your experience with WPI makerspace facilities?
    a. Stults has been the Interim Director for Foisie from building development to last year and is currently the Interim Director for Makerspaces. She also has experience running the Advanced Prototyping Lab in Higgins since 2010.
2. **Facilities at WPI:** Which facilities and equipment on campus do you think might be particularly promising for a challenging yet safe and successful hands-on engineering experience for 8th-grade students?
    a. She recommends reaching out to Washburn and Foisie.
    b. Washburn shops do summer programs all summer. The CNC machines are remarkably safe and really exciting. Contact Ian Anderson and James Lousielle for Washburn information.
    c. Talk with Adam Sears who is the current Director for Foisie about summer availability. In the summer there is less worker availability, but if Camp Reach has enough supervisors it may be possible.
    d. For 3D printers, she recommends an advanced prototyping lab in Higgins. Another option is to use Foisie.
3. **Safety:** Can you provide more resources on the safety aspect of each of the makerspaces? Are there any facility safety documents that describe the machines in each one and room capacity? Is there any training the girls would have to do depending on the space?
    a. Foisie has an access quiz. They may create a modified quiz or do an in-person one. The individual shops would probably have more info.
    b. In general, there is no overall document, but if we have certain makerspaces we are interested in, we should consult the directors for them to get specific safety instructions.
4. **Machinery:** What machinery can we use and what is off-limits? Can we use the 3D Printers?
    a. 3D printer information
        i. Access: For students to have access to 3D printers we need to talk to Adam Sears.
        ii. Use: In Frontiers, another WPI hosted program, they would design a keychain in Solidworks, and then it is printed out for them.
        iii. Interest: 3D Printing sounds exciting until you push a button and wait. She recommends having the finished product printed already to show the girls

instead of waiting for hours. Which can be more engaging than waiting for the advanced prototyping lab is a queue lab; can't do anything yourself.

iv. Ideas: Stults recommends partner students up and let them design something and then upload it into printerOS.

b. Stults says that it is likely that research labs are off-limits. With the makerspaces that are, we are limited to ones that have staff that are trained to supervise. If there are none though, an idea to engage students could be to have a tour of the space.

5. **What machinery would you imagine to be best suited for 8th grade girls?**
    a. She says try to think of a project that can be covered in two days that covers as many aspects as possible like:
        i. Assembling some kind of mechanism that has a 3D printed part, a CNC part and maybe soldering a circuit board that makes it light up. This way it gives a view of all the things you can do in engineering.
        ii. Another suggestion to hop them from thing to thing doing an hour each. The first option shows an interdisciplinary thing but it is harder to do because it one thing hits a snag when it backtracks.
    b. She says to be prepared for things that go wrong and make sure to have a backup.
    c. She mentions we could do an hour workshop and focus on design specifications. Which can prove that the customer is always right.
    d. Consider time constraints, what if they finish too early or need more time.
    e. Have as many people as possible that the participants can talk their ideas through. (volunteers, teachers, students etc).
6. **Workshop Development**: We saw that you had experience in rapid prototyping and have conducted training on that. Do you have any suggestions or resources that could be helpful in conducting training for 8th grade girls? What kind of timeline or support do you think would be helpful for students who may be prototyping for the first time?
    a. Design part in advance and maybe allow them to modify it. Show them how they would do it in CAD but don't make them do it. She mentions that if students aren't fluid in CAD you will spend the entire two days learning CAD.
    b. Don't discount low tech: Having a box full of random stuff and some hand tools, put something together that can solve this problem.
    c. It is important to also balance engineering concepts with something fun to improve engagement.

A.4: Interview Notes Geo Interiano

Minutes for Interview with Geo Interiano (November 10, 2020)

Attendees: Geo Interiano and team members Aleksia Karapanco, Marisa Maltais, A. Ungerer.

Points Discussed:

1. **Experience**: What is your background in working in diversity and outreach within and outside of WPI? What has your department done to promote diversity and how successful has it been?
    a. Interiano is the Associate Director of Admissions for Diversity and Outreach Initiatives and has been with WPI for 1 year. His experience in work has always been in diversity recruitment.
    b. Some of the changes made in his department have been internal to help remove biases from admissions by recognizing the intersectionality of identities of students, and taking advantage of the primarily virtual experience to reach out to more community-based organizations and schools to further exposure for programs and scholarship opportunities.
2. **Diversity and Inclusion**: How would you define inclusion and diversity? What do you think is the state of it at WPI? What is good about it? What can be improved? What do you think needs to be done at other levels so diversity can be accomplished in higher education?
    a. Interiano talks about diversity as two sides of the same coin. Diversity would be the act of bringing people of different identities (e.g. race, sexuality or gender) together while inclusion is the integration within the community and resources diverse populations have to succeed.
    b. Ever since Laurie Leshin came in, it has been getting better in terms of bringing women in, but not as work has been done for racial inclusion as it is still difficult for underrepresented racial populations to be accepted into opportunities such as programs and research.
    c. This is a systemic problem in the school since the ruling body, the Board of Directors, does not reflect the diversity of Worcester, so it is difficult to get them aware and on board with necessary changes to promote inclusion. What is needed is more unity.
3. **WPI Resources**: Does WPI have any resources on promoting diversity and inclusion (e.g. inclusive language guides or bias training)? Where else would you recommend we look to find resources?
    a. We were recommended to look into the Talent and Inclusion Office (HR) for information on anti-racist training and safe zones, and the Office of Multicultural Affairs to get perspective on the state of WPI from students and staff.

4. **Relationships and Culturally-Relevant Support**: From some of our prior research, we learned that it helps when underrepresented minorities are supported through relationship-based and culturally-relevant support. Does WPI have this? How could you imagine that we would integrate something like this into our workshop? Or, are there any resources to better equip our staff members to support diverse populations?
    a. WPI is getting better with a global perspective, but it is not as concentrated on-campus. To help with this, it would be helpful to have more groups to support the different identities of students. However, for the ones we have, it would be important to introduce and share those with prospective students, by explicitly pointing out names and organizations they can go to for support.
    b. It is a common mistake that only women's organizations are listed, but the intersectionalities of the different identities a woman may have are not represented because there is no homogeneous experience that women face.
    c. Interiano also mentioned that staff get basic diversity training, but it is not in-depth enough to encompass and understand what different racial, gender, sexuality and ability groups need.

A.5: Interview Notes Sarah Jane Wodin-Schwartz

Minutes for Interview with Sarah Wodin-Schwartz (November 11, 2020)

Attendees: Sarah Wodin-Schwartz and team members Meghan Hendry, Marisa Maltais, A. Ungerer.

Points Discussed:

1. **Experience:** What's your personal experience on teaching core engineering and critical thinking skills? What is your experience with K-12 STEM education? What is your experience with Camp Reach?
    a. Wodin-Schwartz has been teaching at WPI for 5 ½ years on core technical skills for sophomores in Mechanical Engineering.
    b. Most of her experience in teaching middle school girls is with Camp Reach for 3 years (with two summers of camp).
2. **Developing STEM Curriculum**: How do we determine what is age-appropriate STEM curriculum? How can we translate age-appropriate curriculum into an interesting project-based experience? How do you, as a professor, change theory into a practice students can learn from hands-on?
    a. To find an age-appropriate curriculum, we were recommended to look into Massachusetts education standards and to consult middle school teachers.
    b. To translate curriculum into project-based learning, Wodin-Schwartz recommended that we use backwards design in which we define a clear goal of the learning outcome and structure the activity to revolve around that skill. To do this, it helps to have physical interactions and show examples or give demonstrations.
3. **Project Themes:** What STEM themes are going to keep middle schoolers engaged? What process do you go through to brainstorm ideas? What is a good way to incorporate themes into it?
    a. To find interests, it's best to ask students directly and to engage them in the whole process, it's helpful to let them see the end results of the work and being a part of each step.
    b. An idea given to create workshop ideas was to look at a theme and to recreate or redesign a piece of technology that is associated with it. For example, if the theme was the environment, we could have students redesign a recycling bin or a garbage grabber.
4. **Makerspaces at WPI:** Which facilities and equipment on campus do you think might be particularly promising for a challenging yet safe and successful hands-on engineering experience for 8th-grade students? What type of training would be necessary?
    a. One of the spaces recommended was in Foisie which is good for getting hands on. We were recommended to consult Adam Sears for more information about it and

the safety training that the space provides for university students so that it could be adapted for middle schoolers.

b. Another space was Washburn, but Wodin-Schwartz was concerned that it would be busy in the summer for other programs and there is a chance it would be less of a hands-on experience, since the machinery is more dangerous.

5. **Workshop:** What kind of structure would be useful for a project workshop? Is there a known learning time that is recommended to teach students how to use these facilities?
    a. For creating the workshop itself, we were recommended to get things started quickly and not front load all the material since girls will want to get working and it may lose engagement, or have hands-on activities throughout the process. It is important to keep them busy and include games and breaks.
    b. It would be helpful to have girls learn from their mistakes and reflect and iterate as part of the learning process.
    c. There is a learning time for teaching hardware and software. Wodin-Schwartz recommended that we multiply our learning time by two while understanding that the learning curve is different for everyone or to have a test run with a group of girls.
6. **Inclusion:** Do you have any recommendations on how to ensure our project is inclusive to girls of color and girls from lower socioeconomic levels? Have you made any observations of this in the past when working with Camp Reach?
    a. To promote inclusion, we could use relevant and broad examples and to be aware of cultural differences when coming up with topics. We would need to experiment to find a balance between being broad enough for expression, but strict enough to give direction for students who may not have experience in STEM.
    b. Wodin-Schwartz has noticed that girls tend to stay with people of the same racial and/or ethnic background as themselves. Are there ways we can open a space for girls of different backgrounds to be more comfortable working with each other?

A.6: Interview Notes with Mitra Anand

Minutes for Interview with Mitra Anand (March 2, 2021)

Attendees: Mitra Anand and team member Meghan Hendry

Points Discussed:

1. **Laser Cutting**:
    a. Download Inkscape and create your design for 1 wall of birdhouse (Rectangle with slats)
    b. Print into Full Spectrum Laser Retina Engrave
        i. Use the table below for possible passes
        ii. In the bottom right corner, there is a clock that estimates the time it will take to laser cut that piece

Plywood Thickness	Power	Number of Passes
1/8in	35	3
1/4in	50	4

2. **Materials for Birdhouse**:
    a. Recommends having the rectangular parts of the birdhouse have rectangular slots that fit together that will be reinforced with wood glue
    b. Also could do nuts and bolts
    c. This link has the makerspace website for materials for the laser cutter. It also includes the prices and dimensions. http://makerstore.wpi.edu/shop/category/laser-cutter-materials-3

Appendix B: Makerspace Materials

B.1: Makerspace List

Space Name	Space Type	Safety	Max Capacity	Machine Types	Number of Machines
Washburn	-CNC machining shop	-Would do a safety presentation before using machines	-The computer lab has 12 computers -Could break the girls into stations to fit all 30	-Universal Laser Systems VLS60 Laser Cutter -Makerbot Replicator 2X -Haas MiniMills -Haas SL10s	-1 Universal Laser Systems VLS60 Laser Cutter -1 Makerbot Replicator 2X -3 Haas MiniMills -2 Haas SL10s
ECE 2010 Lab (AK 317A)	-ECE computer Lab	-No safety training needed	-19 computers	-computers with the software listed here: https://hub.wpi.edu/location/9/atwater-kent-317a	-19 computers
BETC	-Biomanufacturing center	-N/A	-20 people	-Has a lot of equipment and may be able to give a hands-on experience	-N/A
Higgins Labs	-computer lab	-No safety training needed	-40 seats	-computers -solidworks and CAD on computers	-40 computers
McDonough	-makerspace	-May be able	-64:16	-3D printers	-24 3D printers

Maker Space and Fitzgerald Prototyping Lab	-prototyping lab	to make a PowerPoint presentation like Washburn that covers the info on safety that is on their Canvas website	workbenches with 4 stools per bench	-Laser cutter -water jet	(prints for all of campus) -1 laser cutter -1waterjet

B.2: Virtual Tour McDonough Maker Space and Fitzgerald Prototyping with Adam Sears

Minutes for Virtual McDonough Makerspace and Fitzgerald Prototyping Lab Tours with Adam Sears (November 19, 2020)

Attendees: James Loiselle and team members Marisa Maltais and Meghan Hendry.

Points Discussed:

1. **Space Contents**: What devices and machines are available in the space for use?
    a. Machines: Laser cutter, water jet, 3D printer
    b. Tools: drills and handheld tools
2. **Space Considerations**: What should we consider when choosing this makerspace?
    a. It may be difficult to fit many projects since the space is for the whole WPI Community.
    b. The space is good for assembling pieces.
    c. The space is not good for lectures and CAD, so it was recommended that we use the computer lab in Higgins Labs.
    d. The water jet is difficult to teach to participants, so between that and the laser cutter, it would be easier to use the latter.
3. **Safety Procedures**: How is safety training typically conducted for students using the makerspace?
    a. The training consists of a Canvas quiz.
    b. For a more in-depth training, we could look at what Mass Academy does for students or what Washburn Labs does.
4. **Workshop Considerations**: Suggestions by the interviewee on developing a workshop that is interesting.
    a. For first-time CAD users, it is easier to teach with TinkerCAD or GoogleSketchup.
    b. If using a 3D printer, it's best to let it print overnight since it takes a long time.
    c. Talk to Kevin Harrington who runs the robotics lab for more ideas.

B.3: Virtual Tour Washburn Shops with James Loiselle

Minutes for Virtual Washburn Tours with James Loiselle (November 23, 2020)

Attendees: James Loiselle and team members Marisa Maltais and Meghan Hendry.

Points Discussed:

1. **Space Contents**: What devices and machines are available in the space for use?
    a. In the back of Room 107, there are 12 computers with SolidWorks, but it may be too advanced for students.
    b. There are 7 machines: 1 Universal Laser Systems VLS60 Laser Cutter, 1 Makerbot Replicator 2X, 3 Haas MiniMills, 2 Haas SL10s
2. **Safety Procedures**: How is safety training typically conducted for students using the makerspace?
    a. The training consists of a basic shop safety presentation.
    b. Machines have multiple 'emergency buttons' on the machine itself and on the walls.
    c. To use the machines, students need to have appropriate attire such as closed-toes shoes, safety glasses and non-baggy clothing that covers the skin.
3. **Workshop Considerations**: Suggestions by the interviewee on developing a workshop that is interesting.
    a. How to form the activity?
        i. Put students in groups randomly.
        ii. Reserve makerspaces.
        iii. Have filler activities in case students finish the step or activity earlier (e.g. building tower competition).
        iv. Make sure there is a balance of learning and fun. For example it could be a fun workshop activity, but incorporates math and physics principles.
    b. How to teach students the activity?
        i. Have an instructor help out step-by-step.
        ii. Have tutorials, but other options as well since not every student's learning style is the same.
    c. How can we keep students interested in the activity?
        i. This age group can be difficult to keep engaged for a long time.
        ii. We were suggested to do things that require a lot of attention-span in the morning.
        iii. Give them Fusion360 accounts so they can keep working on it after they leave. (Note that accounts are free).
4. **Workshop Ideas**: Ideas by the interviewee based on workshops that have been done in the past.

a. Bottle Rockets: Fire off rockets with a different type of nose cones or without nose cones
b. Egg Drop: Build and drop off Earle Bridge
c. Steam Engine: Design and Make components
d. Name Tag: Use CAD to design a name tag and a laser cutter to cut it out
e. Bridge design: Make and break bridges in Goddard with a 3D printer

Appendix C: IRB Materials

C.1: IRB Approval Letter

WORCESTER POLYTECHNIC INSTITUTE

100 INSTITUTE ROAD, WORCESTER MA 01609 USA

Institutional Review Board
FWA #00015024 - HHS #00007374

Notification of IRB Approval

Date :	03-Nov-2020
PI:	Demetry, Chrysanthe
Protocol Number:	IRB-21-0165
Protocol Title:	Engineering Experiences for Middle School Girls
Approved Study Personnel:	Ungerer, Alyssa~Karapanco, Aleksia~Maltais, Marisa~Hendry, Meghan~Demetry, Chrysanthe~
Start Date:	03-Nov-2020
Expiration Date:	02-Nov-2021
Review Type:	
Review Method:	Expedited Review
Risk Level:	Minimal Risk
Sponsor*:	

The WPI Institutional Review Board (IRB) approves the above-referenced research activity, having conducted a review according to the Code of Federal Regulations (45 CFR 46).

This approval is valid through 02-Nov-2021 unless terminated sooner (in writing) by yourself or the WPI IRB. Research activities involving human subjects may not continue past the expiration date listed above, unless you have applied for and received a renewal from this IRB.

We remind you to only use the stamped, approved consent form, and to give a copy of the signed consent form to each of your subjects. You are also required to store the signed consent forms in a secure location and retain them for a period of at least three years following the conclusion of your study. You are encouraged to use the InfoEd system for the storage of your consent forms.

Amendments or changes to the research must be submitted to the WPI IRB for review and approval before such changes are put into practice.

Investigators must immediately report to the IRB any adverse events or unanticipated problems involving risk to human participants.

Please contact the IRB at irb@wpi.edu if you have any questions.

*if blank, the IRB has not reviewed any funding proposal for this protocol

C.2: IRB Approved Consent Form

Designing and Engineering Experience for Girls in Camp Reach

PARENT INFORMATION & CONSENT FORM

Camp Reach is a summer engineering outreach program for middle school girls, offered since 1997 at Worcester Polytechnic Institute (WPI). The Office of Pre-collegiate Outreach Programs at WPI has asked some WPI student investigators to create a project-based workshop experience for Camp Reach, one that utilizes WPI makerspace facilities and is designed to promote inclusion.

You/your child will participate with about 10 other girls as a co-designer of the workshop. Participation will involve multiple virtual informal meetings. Participants will be on a 60 to 90 minute Zoom call with the WPI Student Investigators: Meghan Hendry, Aleksia Karapanco, Marisa Maltais and Alyssa Ungerer. All WPI student investigators on the calls will have cleared a Criminal Offender Record Information (CORI) background check. The phases of the project will involve the following topics on these target dates:

1. **(11/15/2020)** Getting to know each other, discussing school life, inclusion at school, interests, and problems girls want to solve in their communities.
2. **(12/06/2020)** Narrowing down workshop ideas
3. **(02/14/2020)** Testing workshop via a virtual setting and providing feedback.

Only the demographics and grade level of the group of participants will be reported. Individual level data about your child will NOT be reported. Data will be identified with a different name rather than with your child's name. Data from the Zoom meetings will be recorded with note-taking and an audio recording of the call. Information collected will be used to create a workshop that will be most interesting to girls in future Camp Reach programs. This study involves minimal risk, as the probability and magnitude of harm or discomfort anticipated are not greater than those ordinarily encountered in daily life.

Your/your child's participation in this project is voluntary. Girls who participate in all three meetings will receive $50. Your decision not to participate will not result in any penalty to you or your child and will not affect any future interactions with WPI. Your child may decide to stop participating in the research at any time. During the study, your child is not required to answer all questions by the project coordinators. Data obtained in this study will become the property of the investigators and WPI. If you or your child withdraw from the study, data already collected will remain in the study.

For more information about this project or about the rights of project participants, or in case of project-related injury, please contact the Principal Investigator, Prof. Chrysanthe Demetry (Email: cdemetry@wpi.edu), the project sponsor Suzanne Sontgerath in Pre-Collegiate Outreach Programs (Email: ssont@wpi.edu) and/or the Student Investigators (Email: gr-IQPMSG@wpi.edu). You may also contact the chair of the WPI Institutional Review Board (Professor Kent Rissmiller, Phone: 508-831-5019, Email: kjr@wpi.edu) or WPI's Human Protection Administrator (Gabe Johnson, Phone: 508-831-4989, Email: gjohnson@wpi.edu).

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

APPROVED BY
WPI IRB 1
11/3/20 TO 11/221

□ As a parent/legal guardian, I give permission for my child, _____, to participate in this project.
Your child's Name

□ As a parent/legal guardian, I do NOT give permission for my child, _____, to participate in this project.
Your child's Name

Parent/Guardian Name_____ Relationship to Child:_____

Parent/Guardian Signature _____ Date:_____

Participant's Name _____ Date:_____

Participant's Signature _____ Date:_____

APPROVED BY
WPI IRB 1
11/3/20 TO 11/221

C.3: IRB Consent Script

IRB 21-0165 Engineering Experiences for Middle School Girls

The following script will be used during the introductory portion of the first focus group to revisit key aspects of the consent form, assure confidentiality, and to field questions and concerns.

Good evening everyone!

Before we begin the focus group, we would like to remind you about the consent form you signed earlier and some of the important parts of it.

The consent form you and your guardian signed expressed permission to participate as a co-designer of our project, Engineering Experiences for Middle School Girls at Camp Reach. As a co-designer, we hope that you will participate in a series of three focus group meetings, including this first one tonight.

During the focus groups, we'll be asking questions and having conversations regarding workshop themes and inclusion, asking you to help us to narrow down ideas and to provide feedback for the final workshop idea. During the meeting we'll be taking notes and making an audio recording so that we can capture all of your ideas and contributions. We want to emphasize that everything you share will be confidential. We won't be recording your real names, and we will delete the audio recording at the end of the project. We also ask that each of you keep our conversations confidential—that when others share personal things, you will not share them outside the group. Are you on board with that? Can you give a thumbs up?

We also want to emphasize that you are not required to answer all of our questions. Additionally, you can choose to stop participating in this project at any point in time. If you choose to stop participating, you may leave the Zoom call, or send us an email between meetings.

Does anyone have any questions or concerns about what we'll be doing together?

C.4: IRB Recruitment Letter

Add Stamped IRB consent form
Subject line : Become a Workshop Co-Designer With WPI Students!
Dear <<Participants name>>

You are invited to participate as a co-designer for a Camp Reach workshop due to your interest in Pre-collegiate Outreach Programs at WPI! As a co-designer, you would work with four students at WPI, and participate in three focus group meetings virtually over Zoom. In these meetings we will have discussions on what you are interested in, and would like to see in a Camp Reach workshop. You will help us brainstorm ideas, choose the workshop to develop, and then, we will redesign and improve the workshop based on your feedback!

Camp Reach has been hosted by WPI since 1997 and is a program for middle school girls in Worcester, MA that seeks to bridge the gender gap in science, technology, engineering, and mathematics (STEM) by teaching girls how to think like engineers and give them the confidence to solve problems. Through working with us you could help empower girls like you to become involved in STEM and become confident in their abilities in STEM!

The focus group meetings will be held on **11/15/2020**, **12/06/2020**, **02/14/2020**, from **5-6:30 PM (EST) on Zoom. All meetings will be held virtually to eliminate risk of COVID-19. To compensate you for your time, all attendees will receive $50 for participating in all three meetings.**

The focus group will have a total of ten middle school girls and we will meet three times. Each meeting will include introductions and ice-breakers.

- **In the first meeting,** we want to learn about you and how you feel about STEM, what you are interested in learning about, and doing with CAMP REACH. We will incorporate these experiences into the workshop design.
- **The second meeting** will consist of discussing ideas and sharing opinions on which workshop seems the most interesting and what you believe is needed to make the workshop experience fulfilling.
- **In the final meeting** we will virtually test the workshop you chose and helped design and provide another opportunity for feedback. Throughout each stage of workshop creation, you will work with the WPI student researchers as co-designers and as an instrumental part of our team. Your voice matters and we really value your input. No experience is needed to contribute to this project—just come as you are!

There is a consent form attached that gives more information for parents. **If you, the daughter/participant, is interested and able to attend all the focus group sessions, please email us back at gr-IQPMSG@wpi.edu by Thursday 11/12/2020 by 5PM to RSVP. We have**

extended the deadline to give you all more time to decide if you would like to join us! To be eligible to participate, you must attach the signed consent form with your email. Feel free to contact us if you have any questions. We look forward to working with you and thank you in advance for supporting girls like you in learning about and thriving in STEM!

See you soon!
Meghan, Aleksia, Marisa and A.

Appendix D: Focus Group 1 Materials

D.1: Focus Group Training with Irene Shaver

- Data → build up of ideas during each group
- During the focus group (if we get insights or ideas, write about them so that we remember it)
    - Compare notes and discuss trends
- We can use our own notes during the event
- Have a "Zoom personality"
    - Present ourselves in a way that makes others feel included
    - Have warmth and pay attention to others
- Divide up work: rotate team positions (notes, leader, support/clarification, time keeper)
    - Use flow to determine how to rotate work
    - Could use our own growth points to determine who does what
    - Give each person a chance for each role
    - Do a run through on what we want to do
- Risks
    - We want to make experiences low risk: how can we make the beginning stages less risky so people feel compelled to share in the more heavier discussions.
    - Set the tone of the room. Share expectations.
    - Talk about misconceptions in the beginning → we address the problem head forward
- Questions: Re-evaluate where we want them to end up
    - We don't only want to end at the problems: we want to find strategies for overcoming them
- Focus Group is going to be a design process
    - First step is going to be empathizing
        - Add follow up questions
- Questions
    - Engineer: we can maybe have drawing for it → we can see their biases
    - Learning in school: What have you done in school, what do you enjoy about the projects? → ask them directly about it.
        - If they had experiences, ask them about what they have learned or how they felt about it (comfortability)
        - Engaging minorities in the curriculum: talk about the culture and the problems in the past. Address them head on.
    - Inclusion questions: recognize setback and inform that we can overcome them
        - We can make a scenario: e.g. boys take over a project

- They talk about what they would say for advice: give them a leadership role in this
- Give them problem-solving skills
- Make it personal

D.2: Focus Group Agenda 1 (11/15)

WPI IQP Focus Group Meeting Agenda: Sunday, November 15, 2020, 5-6:30 pm on Zoom.
Engineering Experiences for Middle School Girls - Camp Reach
Hosts: Meghan Hendry, Aleksia Karapanco, Marisa Maltais, A. Ungerer

1. Reminders: Consent and Project Participation And Ground Rules.
    a. First reiterate some of the consent form including:
        I. Reminding students that they will only have their racial demographic and grade levels documented
        II. Names will not be used and they will be assigned code-names for research
        III. Data will be recorded through audio call on Zoom and note-taking
        IV. Students are not required to answer all questions and may stop participating at any time
    b. Ground rules before we start:
        I. Be kind, don't speak when others are talking.
        II. Remind them that this is a confidential space and we want to hear what is on your heart but please don't feel like you have to share information that makes you feel uncomfortable.
        III. Make sure they know this is a time to learn from each other, and give each other the benefit of the doubt and recognize we are in a learning process together.
        IV. Remind them to feel free to ask questions if you are ever confused. They can ask out loud or use the chat box and we will address them right away.
2. Introductions
    a. Introduce each of the Student Investigators (name, grade level, major, interests, fun facts, why we love this project)
    b. Project Introduction: Explain what Camp Reach is, our project and our goal.
    c. Encourage students to introduce themselves if they would like (name, grade level, interests, fun facts)
3. Ice breakers + Questions to get to know each other!
    a. What do you see yourself doing in 10 or 20 years?
    b. Have you ever made something before, like art or a poem or a science experiment? What are you proud of about it?
    c. What are three things you love about yourself? It can be physical features, skills, parts of your personality.
4. *Discussion Questions
    a. What is your favorite school subject and why?
    b. What do you think an engineer is? Draw what you picture in your head.
    c. What are interesting topics that you have learned in math and science? Have you applied any of those to real life (e.g. projects, experiments, etc.)?

d. What kinds of problems do you notice in the world, your home or at school?

5. Quick 5-10 min Break.
6. Game: Present about current issues in STEM and diversity and choose if its (T/F)
    a. Display the numbered statistics about interest in STEM vs translation to career.
    b. Ask them to think about the statistic and if it is TRUE or FALSE. We will say "go" and they will all send it in the chat at once with the number and then TRUE or False. (ex: 1. FALSE)
    c. Follow up questions after all the statistics: Why do you think this is the case? Why is this a problem?
        I. 74% percent of high school girls across the country are interested in the fields and subjects of STEM. (T)
        II. A national report on college freshmen major/career interests shows that, on average, 10% of young women intend to major in a STEM field, compared to 70% of young men. (F)
        III. Perceived gender barriers are still high for girls and may help explain why STEM fields aren't their top career choices. (T).
        IV. Caucasian girls are more likely to know someone in a STEM career, compared to African American and Hispanic and Latina girls. (T)
        V. African American and Hispanic girls are more interested in how things work than Caucasian girls. (T)
        VI. More Caucasian girls feel that employers in the fields of STEM don't usually want to hire women, compared to African American girls. (F)
7. *More Discussion Question
    a. Describe a time when you felt excluded from something? This can be an activity, game or experience. Why do you think you were excluded?
    b. Have you ever had anyone treat you differently because of how you look? How does that make you feel? Why?

*Hosts should be prepared to discuss their own experiences to help girls feel more comfortable with speaking about their experiences.

D.3: Focus Group 1 Notes and Observations

Introductions

- Participant F: (she/her/hers)
    - 7th grade
    - sewing → just got a machine and made a doll with it
- Participant E: (she/her/hers)
    - 8th grade
    - piano, softball, crayfish pet
- Participant B: (she/her/hers)
    - 7th reading and writing
    - Likes blue
- Participant D: (any pronouns, prefers she/her)
    - 9th grade and 13
    - Anime, drawing, writing and reading
- Participant G: (she/her/hers)
    - 8th grade
    - Singing and dancing, play violin
- Participant H: (she/her/hers)
    - Interested in the arts, has a guinea pigs
- Participant A: (she/her/hers)
    - 8th grade
    - Clarinet, chocolate, anime
- Participant C: (she/her/hers)
- Trends: lots of people interested in art and music

Ice Breakers

What do you see yourself doing in 10-20 years?

- Participant D: biomed field, medical, surgeon
- Participant E: also in medical field (chemical field) like a researcher

Have you ever made something before, like art or a poem or a science experiment?

- Participant D: creativity → drew a realistic drawing of a famous actor
    - Essay: got a lot better at it
- A lot of creativity and drawing: people like seeing good finished products

What do you like about yourself?

- Trends: lots about physical features and mentality. Like to see growth

Discussion Questions

What is your favorite school subject and why?

- Participant E: like algebra math because I'm good at it. Fun to do something you are good at and understand
- Participant G: algebra - enjoy understanding and doing it
- Participant D: science and math
    - Like learning science because you can learn about other people (psych, body)
    - Math: likes that it is easy, fun to do things that you like and understand
- Participant H: history because it is there for you and less tedious work

What do you think an engineer is?

- Participant H: broad field? How?
    - Not too much exposure

Interesting topics in math and science?

- Participant D: Statistics and physics
    - Self-learning and picking up new things during quarantine
    - The way the world works
- Participant G
    - Learning how to budget for a school project

What kinds of problems do you notice in the world, at home and at school?

- Participant H: low-budget families needing support in the world
    - You have to educate people
    - Comment: A good video that explain my point a lot better is Jaiden Animations " Thing about relationships i wish someone told me"
- Posting about awareness
- Participant D: toxicity in religion → zone out different beliefs and sexuality
    - Toxicity online: take a step back from going head first
        - Misinformation
        - Affect us negatively. Mental health.

Game + Discussion about discrepancy between interest and results

- First statistic: most people thought it was true → answer was true
- Second statistic: most people thought it was false → answer was false
- Third statistic: most people thought it was true → answer is true
- Fourth statistic: most people thought it was true → answer is true
- Fifth statistic: most people thought it was true → answer is true
- Sixth statistic: most people thought it was false → answer is false
- Overall: pretty aware of the statistics and it makes sense to them

- Why discrepancy
    - Stereotypes
    - Authority, family

Exclusion

- Participant D: ideas were not acknowledged, opinions belittled
    - Exclusion from games: it makes you feel hurt and not wanted
- Gendered sport activities: gym teacher tells girls instead of sports

People treating you differently

- Participant D: bullied because of skin color (only black girl in private school. Lots of racism)

General notes

- Very aware of things

D.4: Focus Group 1 Trends and Similarities

Introductions

Interests:

- Reading/writing
- Singing/dancing
- Music: Piano,clarinet
- Sports: softball
- Being creative: sewing, drawing
- Animals: guinea pigs, crayfish

Ice Breakers

What do you see yourself doing in 10-20 years?

- Medical field: working in a lab, or a doctor
- College: taking classes, about to graduate
- Owning pets: cats, dogs

Have you ever made something before, like art or a poem or a science experiment?

- Arts and crafts: legos, cut up newspaper into animals, drawing pictures, made a rag doll
- Writing: poems, stories

What do you like about yourself?

- Physical features: Hair
- Mentally: mind, the way they think, how smart they are, how they are hard working
- Note: Some found that they had never really thought about what they liked about themselves before

Discussion Questions

What is your favorite school subject and why?

- Math: algebra, numbers (brain workout)
- Science: physics, coding, anatomy (to learn more about yourself and the world)
- History: less work (easier)

What do you think an engineer is?

***didn't really know the different fields of engineering**

- Builder: baggy clothes, building things, working on trains, building robots, building cars
- Computer: robotics, coding
- Lab: lab coat, with goggles

Participant B: “I see someone building a robot or coding at a computer and making things easier for us. I picture someone in a lab coat with goggles”

What are interesting topics that you have learned in math and science? Have you applied any of those to real life (e.g. projects, experiments, etc.)?

- Physics: Newton's 3 Laws of Motion
- CS: How to code through code.org
- Math: incorporate numbers in new ways

What kinds of problems do you notice in the world, at home and at school?

- Low income families/poverty
- Trash on the street
- Climate change
- Animal cruelty
- Inequality
- Sexsim
- Racism
- Getting bullied because of how you look: skin color, hair, facial features
- Toxicity in religion
- Online bullying because of diff beliefs

How to solve these problems: Educate people, show awareness, protest, host more programs, talk about things more freely.

Game

***almost every girl got the statistics correct**

- Sexism: scared to be a woman in the field because of men
- Less Resources: not enough, less connections
- Stereotypes: women of color
- Can't afford: education, college, resources, STEM programs

Exclusion

- Gendered sport activities: because they weren't a boy, gym teacher telling the girls to do a simpler workout
- Being avoided by a teacher: talking about a racism and having the teacher skip over your opinion

People treating you differently

- Racism: bullied because of skin color, only black girl in private school, bullied by boys
- Gender stereotypes: girls are suppose to cook

Memorable Quotes from the girls

Participant G: “We were talking about racism and i said something and the teacher skipped over my chat and it made me feel like she doesnt think that's important they weren't ready for my amazing and strong opinionated thoughts”

Participant B: “So i'm biracial and the boys in my class were really into rating girls by how they look and they told me that I was a 3 because my skin is mixed and not just one color but I didn't listen to them and I just told myself that it doesn't matter what they think”

Participant B: “I feel like a lot of people, women in particular, who are afraid to do what they want because a lot of men or authority figures they look up to put them down or tell them they can't do that.”

D.5: Focus Group 1 Slides

Welcome to our First Focus Group

Engineering Experiences for Middle School Girls at Camp Reach

Meghan Hendry, Aleksia Karapanco,
Marisa Maltais, Alyssa Ungerer

Reminders: Consent and Project Participation And Ground Rules.

- **Consent Form:** You and your guardian signed a consent form to participate as a co-designer.
- **Data:** Recording data with note-taking and audio recording on Zoom
  - Zoom recordings deleted at end of project
- **Confidentiality:**
  - Using code names so nothing is traced to you.
  - Please keep all discussion within our group!
- **Risks:** Not more than daily life
- **Your choice:**
  - You can choose to answer each of the questions we ask.
  - You can decide to stop participating at any time.
    - Leave Zoom call.
    - Send us an email.

Ground Rules before we start.

- **Be kind,** don't speak when others are talking.
- **This is a confidential space** and we want to hear what is on your heart but please don't feel like you have to share information that makes you feel uncomfortable.
- **This is our time to learn from each other,** and none of us are perfect, so we may make mistakes, lets give each other the benefit of the doubt and recognize we are in a learning process together. Feel free to ask questions if you are ever confused. You can ask out loud or put in the chat box and we will address you ASAP!
- That being said, can we make a commitment to be kind to each other and to speak primarily from our own experiences?

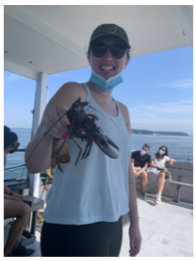
Any Questions or Concerns?

Now We Can Finally Introduce Ourselves!

Now It's Time to Introduce Yourselves!

- ★ Preferred Name and Pronouns
- ★ Grade Level
- ★ Interests
- ★ A Fun Fact about Yourself

Meghan Hendry *she/her/hers*

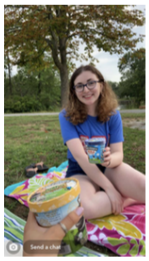


- ★ **Grade:** Junior
- ★ **Major:** Mechanical Engineering
- ★ **Interests:** I like reading and hanging out with my friends and family.
- ★ **Fun Facts:**
  - I'm from Plymouth, MA.
  - I LOVE coffee.
  - I like exploring nature and new places.
- ★ **Why I love this project?**
  - I am passionate about STEM and I want girls to have an opportunity to learn about STEM as early as possible.
  - I love female empowerment and think that knowledge and opportunity help empower women.

Aleksia Karapanco *she/her/hers*

- ★ **Grade:** Junior
- ★ **Major:** Computer Science and Minor in Political Science & Law
- ★ **Interests**: Love reading during my free time, spending time in nature and painting.
- ★ **Fun Facts:**
  - I was born in Athens, Greece but my family and I are Albanian.
  - I know three languages (Albanian, Greek and English).
  - My favorite season is Fall.
  - My favorite color is yellow.
- ★ **Why I love this project?**
  - I want girls to know they are capable of doing and being whatever they set their minds to.
  - There is no limit to what we as women can accomplish, dream big!

Marisa Maltais *she/her/hers*



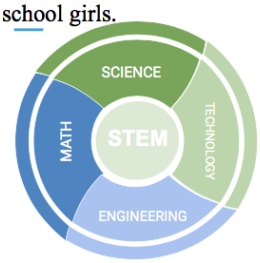
- ★ **Grade:** Junior
- ★ **Major:** Biomedical Engineering (Biomaterials/Tissue Engineering)
- ★ **Interests:** I like getting boba, singing, and playing guitar.
- ★ **Fun Facts:**
  - My favorite food is sushi.
  - My favorite color is blue.
  - I'm from Springfield, MA
- ★ **Why I love this project?**
  - I went to a STEM middle school and want other girls to have the opportunity of being exposed to STEM at an early age.
  - "Inspire the woman. Impact the world."

Alyssa Ungerer *she/her/hers*

- ★ **Grade:** Junior/Senior
- ★ **Major:** Electrical and Computer Engineering
- ★ **Interests:** I like coding, anime, gaming, art, getting boba and buying takeout
- ★ **Fun Facts:**
  - I'm from California (yay remote learning!)
  - My favorite food is mapu tofu or any spicy foods
  - I've been working a lot on character design in art
  - I've been stung by a jellyfish before
- ★ **Why I love this project?**
  - Give all girls more career options
  - Strong believer of diversity

What is Camp Reach and What is our Project Goal?

Camp Reach is a STEM intervention program for middle school girls.



Goal: Design a multi-day workshop for Camp Reach that utilizes WPI makerspace facilities to create a sophisticated engineering experience for 8th grade girls and is designed to promote inclusion.

Now It's Time to Introduce Yourselves!

- ★ Preferred Name and Pronouns
- ★ Grade Level
- ★ Interests
- ★ A Fun Fact about Yourself

Ice breakers + Questions to get to know each other!

1. What do you see yourself doing in 10 or 20 years?

2. Have you ever made something before, like art or a poem or a science experiment? What are you proud of for it?

What are three things you love about yourself ? It can be skills, parts of your personality, physical features.

Discussion Questions

What is your favorite school subject and why?

What do you think an engineer is? Draw what you picture in your head.

What are interesting topics that you have learned in math and science? Have you applied any of those to real life (e.g. projects, experiments, etc.)?

What kinds of problems do you notice in the world, your home or at school?

5. African American and Hispanic girls are more interested in how things work than Caucasian girls. (T or F)

6. More Caucasian girls feel that employers in the fields of STEM don't usually want to hire women, compared to African American girls. (T or F)

Let's Discuss

- Why do we think there is a discrepancy between interest and career choice?
- Could there be social or economic barriers?
- What do we think there are?

Describe a time when you felt excluded from something? This can be an activity, game or experience. Why do you think you were excluded?

Have you ever had any accommodations made? If so, what were they and how did it make you feel?

Have you ever had anyone treat you differently because of how you look? How does that make you feel? Why?

Thank you everyone for your time!

A few more reminders...

- ★ And dont forget everything we talked about today is confidential.
- ★ Focus group #2: Sunday December 6th 5:00 -6:30pm
- ★ Focus group #3: Sunday February 14th 5:00 -6:30pm
- ★ The Zoom link will be the same but we will send out a reminder before the meetings!

Appendix E: Focus Group 2 Materials

E.1: Focus Group Agenda 2 (12/06)

WPI IQP Focus Group Meeting Agenda: Sunday, December 6, 2020, 5-6:30 pm on Zoom.
Engineering Experiences for Middle School Girls - Camp Reach

Hosts: Meghan Hendry, Aleksia Karapanco, Marisa Maltais, A. Ungerer

1. Introductions
    a. First reiterate some of the consent form including:
        i. Reminding students that they will only have their racial demographic and grade levels documented
        ii. Names will not be used and they will be assigned code-names for research
        iii. Data will be recorded through audio call on Zoom and note-taking
        iv. Students are not required to answer all questions and may stop participating at any time.
    b. Ground rules
    c. Re-introduce each of the Student Investigators (name, grade level, major)
    d. Encourage students to re-introduce themselves if they would like (name, grade level)

2. Project Recap
    a. Last focus group data trends
    b. How that factored into ideas
    c. What they will be doing for the next part + engineering design process

3. Present Each Ideas + Discussion
    a. Present slide show of the different ideas we have and describe the themes, makerspace facility and general layout of the program.
    b. Guide Questions:
        i. What makes a space inclusive or welcoming to you? How can we make this activity inclusive?
        ii. How can we personalize the activity for participants? Is the creative expression element enough? What could be added?
        iii. If you are learning something new, what starting material helps you? What kinds of learning methods are you comfortable or familiar with?
        iv. What safety aspects would you be concerned about when learning about machinery? What kinds of training do you find easy to understand and would make you feel safe?

v. We want the projects to be a collaborative opportunity. How many people do you imagine could work on this so that each person can learn and contribute?

c. Open up to questions and feedback about ideas.
d. Present survey: describe what each question is, and ask if anyone has any questions about the survey.

4. Conclusion
    a. How will this be used in the future
    b. Explain how they were engineers themselves and thank them for being a co designer

E.2: Workshop Idea Pitches

Pitches

Idea	Pitch
Creating a functional planter to grow your own food	Growing your own food puts you in control over the things that end up on your plate, and teaches how environmental resources like soil, water and sunlight work together to produce useful plants. Participants can get creative and can customize their own planter by using CAD. The planter designed will be 3D printed and participants are able to take the planters home and see their plants grow in real time. Designing your own functional planter will help participants learn more about how to design, plant and grow their own plants while at the same time learn more about environmental engineering.
Creating a birdhouse	Birdhouses play a role in promoting a healthy backyard ecosystem in residential areas. In this project, participants will learn about the importance of birds by working in teams to design pieces of the birdhouse in CAD. They will gain experience in using a laser cutter in Foisie or Washburn makerspaces to cut out all the pieces, and as a team, they will discuss and experiment with the best way to assemble the full design using tools or glue. Each piece will be cut out multiple times so that all members will be able to take home a birdhouse that is a product of everyone's design input. At the end, team members will have a chance to reflect their design experience while expressing themselves through painting.
Design your own version of a fidget spinner or fidget cube.	Fidget spinners and cubes are really helpful for people with anxiety and stress. The participants will learn about those things and how the cubes could help. They will then design their own version that could help students. They will learn about mental health and become more aware of how objects that may seem like toys can really be beneficial to people. The designs they come up with will be 3D printed and then assembled so every participant can take their design home.
Design your own board game.	The participants will create their own board game of any theme they are interested in. This can be something they like, a hobby or maybe a game that can teach people new facts (e.g. trivia on climate change or learning about engineering statistics, etc). The participants will have to design at least 4 unique game pieces (think of chess or monopoly pieces) on CAD that can be printed out and used for the game. They get to incorporate their own interests with the game theme and strategy and there are creative aspects of

	it where they can design the board. Each person in the group gets a chance to design their own piece and come together at the end for a final product. An idea for an easier CAD can be to make game stands and pieces that fit in there and use the laser cutter to design a look for it and cut out the part.

E.3: Focus Group 2 Notes and Observations

Idea 1: Birdhouse

- Heavy on communication: Set up some times to talk about rules and create guidelines to make sure all members are heard
    - Create discussion questions so that its guided and people are understanding of each other's expectations
- Teamwork
    - Teamwork is an important skill to have but it is important to have self-development. → Some girls mentioned that they wanted to work themselves.
    - "Maybe on our own we could sketch ideas or draw prototypes but then we all come together in a group to collaborate" - Mikayla
    - Balance of teamwork and personal growth
- Creative Expression: Like the painting at the end with discussion, having a choice of materials.

Idea 2: Planter

- Using real-time demonstrations helps.
    - Also having a side reference sheet is helpful to refer to since demonstrations don't always click right away.
- Learning material
    - Have people there who are familiar with CAD to help you
    - Make a step-by-step guide to start with or a beginning pot for reference and girls could customize it?
- Customization
    - Supply markers or stickers to decorate at the end for fun
    - Choosing what seeds to plant and having a different variety of seeds to plant.
- Teamwork - Group design and researching and CAD individually.
    - Difficult to work with CAD with other people on one project

Idea 3: Fidget Spinner

- Starting material
    - Having a template to start with would help for people who are unfamiliar
- Teamwork
    - Leaning toward working alone because girls want to show their individuality, but could use teams for the research in the beginning
- Other options: stress cubes, slime, stress balls
- Relevancy: fidget spinners are not as trendy anymore
- While waiting for 3D printer, have other activities on the side like making slime, making stress balls, origami infinity cube

Idea 4: Design your own board game

- Dividing team ideas
    - 2-6 people per team
    - Working together discussing with teams
    - Each person gets their own part and bring it together
- Starting material
    - Prototype with cardboard
    - Templates for pieces in CAD
- Workshop structure
    - Time limits for each part → learning time management
    - Structure workshop so no one gets left behind because it could get very detailed
- Finishing up the project
    - Nice to have a time at the end to present/play each other's games.

E.4: Data Gathered from Focus Group 2

Idea 1: Birdhouse (Ranked as #1)

- Inclusivity: Have roles in groups, Have time in groups to share opinions so that no one's thoughts are left out, Create discussion questions
- Collaboration: Work individually or in groups, maybe bounce ideas from one another.
- Personalization: Wanted to personalize by painting.
- Safety: How to use laser cutters
- Suggestions: Having a choice of materials like a bird feeder or a birdbath
- Concerns: concern about how this idea would be split up into groups

Anonymous Quote “I love idea 1. I think that it gives a change for people to express themselves and also learn how to work in groups”

Idea 2: Planter (Ranked as #1)

- Inclusivity: Provide variety of seeds to plant so everyone can feel included
- Collaboration: Use CAD separately but work together to design and research
- Personalization: Supply markers or stickers to decorate and personalize their planter
- Safety: Reference sheet or a video to demonstrate how CAD works
- Suggestions: Real-time demonstrations for CAD
- Concerns: Might not be as “fun” as other ideas.

Anonymous Quote: “I love this idea because you are learning how privileged you are and learn about a life skill”

Idea 3: Fidget Spinner (Ranked as #4)

- Inclusivity: Have the option to choose between stress cubes, slime, stress balls, origami etc.
- Collaboration:Work individually
- Safety: Template to start with for CAD
- Personalization: Painting
- Suggestions: Teach others the benefit of fidget spinners and how they can be useful for stress and anxiety
- Concerns: Not as interesting because they aren't as “trendy” anymore

Anonymous Quote: “A way I would improve this idea is allowing the students to read about how fidget items help with people who are very fidgety or ones that need it. Once they are filled with that knowledge I think i would want to make it a lot more, especially if they know it would help others in tough times”

Idea 4: Design your own board game (Ranked as #3)

- Inclusivity: Divide up the board into different pieces for the girls to work on
- Collaboration:Work in teams (2-6 people)
- Safety: How to use laser cutters
- Personalization: Decide their own theme
- Suggestions: Make time for using each others prototype
- Concerns: Concerned about time might need more time to accomplish this idea

Anonymous Quote: “I like this because it will provide for a great hands-on experience. It might take a long time though so maybe make it a small table top game”

E.5: Focus Group 2 Slides

Engineering Experiences for Middle School Girls: Welcome to our Second Focus Group!

Meghan Hendry, Aleksia Karapanco, Marisa Maltais, Alyssa Ungerer

Reminders: Consent and Project Participation And Ground Rules.

Consent and Confidentiality

- ★ You and your guardian signed a consent form to participate as a co-designer.
- ★ Data: Recording data with note-taking and audio recording on Zoom
  - Zoom recordings deleted at end of project
- ★ Confidentiality:
  - Using code names so nothing is traced to you.
  - Please keep all discussion within our group!
- ★ Risks: Not more than daily life
- ★ Your choice:
  - You can choose to answer each of the questions we ask.
  - You can decide to stop participating at any time.
    - Leave Zoom call.
    - Send us an email.

Ground rules before we start.

- ★ Be kind, don't speak when others are talking.
- ★ This is a confidential space, please don't feel like you have to share information that makes you feel uncomfortable.
- ★ Please participate as much as possible we want to hear what you have to say, you are the co designers today!
- ★ Feel free to ask questions if you are ever confused. You can ask out loud or put in the chat box.

Any Questions or Concerns?

Reintroductions

- ★ Name
- ★ Something fun you did over the Thanksgiving break holidays.
- ★ What you plan to do for Winter Break.

Project Recap

Goal: Design a multi-day workshop for Camp Reach that utilizes WPI makerspace facilities to create a sophisticated engineering experience for 8th grade girls and is designed to promote inclusion.

8

Trends and Similarities from Focus Group 1

Interests

- Reading/writing
- Music/Singing/dancing
- Sports
- Being creative: sewing, drawing
- Animals

Favorite Subjects

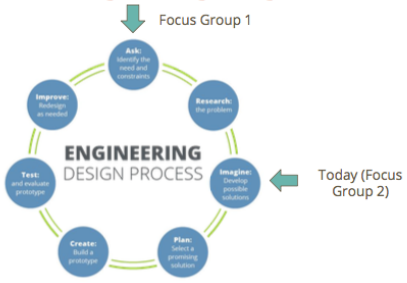
- Math: algebra, numbers
- Science: physics, coding, anatomy

Problems in the World

- Climate change
- Animal cruelty
- Getting bullied (Mental Health)
- Inequality

You are the co-designers, we need your expertise in being a middle school girl!

Where are we in the Engineering Design Process?



Idea Pitches

Questions to Consider

Safety - What safety aspects would you be concerned about when learning about machinery?

Collaboration - How would you split up the roles when working on your CAD or projects.

Personalize - How can we personalize the activity for participants?

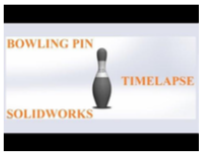
Inclusivity - What makes a space inclusive or welcoming to you?

Equipment the Ideas Use

Laser Cutter

3D Printer (Time Lapse)

CAD (Time Lapse)



Idea #1: Create your own birdhouse.

Learn about benefits of birdhouses.

Design pieces of the house with a team using CAD.

Create the pieces using a laser cutter.

Assemble the house using tools.

Express yourself with painting.

Idea #2: Creating a functional planter to grow your own food

Learn about the benefits of growing your own food at home.

Design the seed planters and planter trays using CAD.

Create the pieces by using 3D Printing.

Assemble the planter using tools.

Express yourself by customizing the planter that's functional and unique for you.

Break 2-5 mins

Idea #3: Design your own version of a fidget spinner or fidget cube.

Learn about how fidget devices can help people who are stressed or anxious.

Design a fidget device using CAD.

Create the pieces of the fidget device using 3D printers.

Assemble your fidget spinner.

Express Yourself through your design!

Idea #4: Design your own board game.

Learn about the benefits of board games.

Design your own game pieces using CAD.

Create your game pieces by using 3D printing and laser cutter.

Assemble the pieces and make the game.

Express yourself by designing a game that fits your interests.

Survey: Rank the ideas.

https://forms.gle/G8bm3pJD4RW38smb9

Thank You!

For any future questions, concerns or feedback, send us an email through our alias: **gr-IQPMSG@wpi.edu**

E.6 Focus Group 2 Survey

Focus Group 2 Workshop Form

* Required

Idea 1: Create Your Own Birdhouse

Learn about the benefits of birdhouses.
Design pieces of the house with a team using CAD.
Create the pieces using a laser cutter.
Assemble the house using tools.
Express yourself with painting.

Idea 1: Create Your Own Birdhouse

Learn about the benefits of birdhouses.
Design pieces of the house with a team using CAD.
Create the pieces using a laser cutter.
Assemble the house using tools.
Express yourself with painting.

Do you have any other feedback about idea 1? *

What do you like about this idea and why? What do you not like about this idea and why? How would you improve this idea?

Your answer

Idea 2: Creating a Functional Planter to Grow Your Own Food

Learn about the benefits of growing your own food at home.
Design the seed planters and planter trays using CAD.
Create the pieces by using 3D Printing.
Assemble the planter using tools.
Express yourself by customizing a planter that's functional and unique for you and watch your plants grow!

Do you have any other feedback about idea 2? *

What do you like about this idea and why? What do you not like about this idea and why? How would you improve this idea?

Your answer

Idea 3: Design Your Own Version of a Fidget Spinner or Fidget Cube

Learn about how fidget devices can help people who are stressed or anxious.
Design a fidget device using CAD.
Create the pieces of the fidget device using 3D printers.
Assemble your fidget spinner.
Express Yourself through your design!

Do you have any other feedback about idea 3? *

What do you like about this idea and why? What do you not like about this idea and why? How would you improve this idea?

Your answer

Idea 4: Design Your Own Board Game

Learn about the benefits of board games.
Design your own game pieces using CAD.
Create your game pieces by using 3D printing and laser cutter.
Assemble the pieces and make the game.
Express yourself by designing a game that fits your interests.

Do you have any other feedback about idea 4? *

What do you like about this idea and why? What do you not like about this idea and why? How would you improve this idea?

Your answer

Rank your favorite workshop ideas from 1st to 4th. *

	Birdhouse	Planter	Fidget Spinner	Board Game
First Choice	○	○	○	○
Second Choice	○	○	○	○
Third Choice	○	○	○	○
Fourth Choice	○	○	○	○

Appendix F: Focus Group 3 Materials

F.1: Focus Group Agenda 3 (2/14)

WPI IQP Focus Group Meeting Agenda: Sunday, February 14, 2020, 5-6:30 pm on Zoom.
Engineering Experiences for Middle School Girls - Camp Reach

Hosts: Meghan Hendry, Aleksia Karapanco, Marisa Maltais, A. Ungerer

1. Introductions
    a. First reiterate some of the consent form including:
        i. Reminding students that they will only have their racial demographic and grade levels documented
        ii. Names will not be used and they will be assigned code-names for research
        iii. Data will be recorded through audio call on Zoom and note-taking
        iv. Students are not required to answer all questions and may stop participating at any time.
    b. Ground rules
    c. Re-introduce each of the Student Investigators.
    d. Encourage students to re-introduce themselves if they would like (name, grade level)
2. Project Recap
    a. Our goal for Camp Reach and how we will incorporate their voice.
3. Focus Group 2 Recap
    a. Last focus group data trends
    b. Which workshop idea was picked
    c. What they will be doing for the next part + engineering design process
4. Present Workshop Agenda
    a. Get feedback from the girls.
5. Introduction to CAD (needs 30-45 minutes)
    a. Slides: Run through the basic slides about the features we will use for TinkerCAD
    b. Go step-by-step on TinkerCAD to guide students in how to make a part with a hole in it.
    c. Discuss feedback including:
        i. CAD instruction: What methods worked (e.g. slides, step-by-step instruction)? Is there anything else that would have helped you to make this part or a more complex part?
        ii. Workshop Agenda: Is timing for this make sense based on the skill level? What resources would make this timing possible?
6. Conclusion

a. Present Survey: Give co-designers a chance to fill out an anonymous survey about the workshop agenda and CAD instruction.
b. Thank our co-designer for working with us on this project and let them know that they will receive a follow-up email soon about reimbursement from participating.

F.2: Focus Group 3 Data Analyzed

Focus Group 3 Data Analyzed

1. Workshop Agenda: What were your impressions of the flow of the workshop on a day-to-day basis? Does it make sense?

- Liked that it had group and individual work.
- Organized.

"Well spread out. It makes sense because each step is given the amount of time needed"

2. Workshop Agenda: What is your favorite part about the birdhouse workshop?

- Assembly and building process part.
- Design the house and express yourself through painting.

3. Workshop Agenda: What can we improve on the birdhouse workshop?

- No major improvements. Good amount of individual and team work.
- Maybe add time for participants to share their different birdhouse designs.

"I think that you need to add a part where maybe they share their design idea with another person and they help each other out"

4. Workshop Agenda: The workshop consists of team research/design/prototyping and assembly, and individual CAD work (with team support). Does this structure make sense? How can we improve it? Are there any concerns about it?

- Structure makes sense, no improvements.

5. Workshop Agenda: Any recommendations to making the workshop more fun? How can we further personalize it to make engineering fun?

- More time to decorate and have various supplies to decorate with.

“Give lots of time to decorate and give lots of different supplies so each person's birdhouse is unique”

6. Intro to CAD: Did the slides/reference sheet help you to understand CAD? What could have been improved?

- Have more detailed reference slides.
- Have a video explanation of CAD to follow through.

“The the slides were very informative what i think could’ve been improved is maybe adding a video on how to work tinker cad”

7. Intro to CAD: Did the step-by-step direction help you to understand CAD? What could have been improved?

- Very helpful.

“Yes I understand the step-by-step directions and I do not think anything should be improved since I understood everything clearly”

8. Intro to CAD: What is your preferred method of learning new concepts at school?6 responses

- Visual and hands- on learning.
- Reading instructions.

“I like to learn new concepts visually at school. I like to have a picture of what is expected.”

9. Overall comments about the whole workshop you helped us plan?

“I loved this so much and I will be making things a lot! Thank you for doing this class. I had so much fun and I am inspired to become an engineer to pursue creative hands-on stuff!”

“I had a fun time helping out!”

“I went into it like i didn’t know how i work tinker cad and i wasn’t confused at all”

F.3: Focus Group 3 Slides

Engineering Experiences for Middle School Girls: Welcome to our Second Focus Group!

Meghan Hendry, Aleksia Karapanco, Marisa Maltais, Alyssa Ungerer

1

Reminders: Consent and Project Participation And Ground Rules.

2

Consent and Confidentiality

- ★ You and your guardian signed a consent form to participate as a co-designer.
- ★ Data: Recording data with note-taking and audio recording on Zoom
  - Zoom recordings deleted at end of project
- ★ Confidentiality:
  - Using code names so nothing is traced to you.
  - Please keep all discussion within our group!
- ★ Risks: Not more than daily life
- ★ Your choice:
  - You can choose to answer each of the questions we ask.
  - You can decide to stop participating at any time.
    - Leave Zoom call.
    - Send us an email.

3

Ground rules before we start.

- ★ Be kind to each other, don't speak when others are talking.
- ★ This is a confidential space, please don't feel like you have to share information that makes you feel uncomfortable.
- ★ Please participate as much as possible we want to hear what you have to say, you are the co designers!
- ★ Feel free to ask questions if you are ever confused. You can ask out loud or put in the chat box.

4

Project Recap

5

Goal: Design a multi-day workshop for Camp Reach that utilizes WPI makerspace facilities to create a sophisticated engineering experience for 8th grade girls and is designed to promote inclusion.

6

Focus Group Recap

7

Recap from Focus Group 2

- ★ The Planter workshop and Birdhouse workshop tied from the Google Form ranking as number 1
- ★ Some of you liked working in groups and others liked working individually
  - We made sure to incorporate both individual and teamwork aspects
- ★ You thought it would be a good idea to have a prototype stage of the workshop
  - We added this aspect into the workshop to help participants visualize the CAD
- ★ You recommended having roles in groups to help promote inclusion and to have time to have everyone share their opinion so all voices of the participants are heard

8

Which Workshop Idea you liked the most

9

The birdhouse workshop provided interesting ways to integrate design thinking and creative expression.

Learn about birds and the benefits of birdhouses and why they help the environment.

Collaborate with others their age to help learn together as a team.

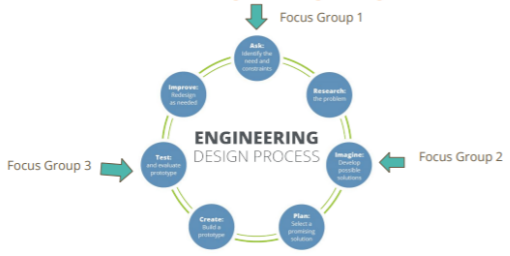
Listen to other team members and bounce off ideas so everyone feels included.

Design pieces of the house using CAD.

Personalize their own design to express themselves.

10

Where are we in the Engineering Design Process?



11

Workshop Agenda (Day 1) (Work in a team)

Introduction with Research and Prototyping

[15 min] Introduce Project

[15 min] Developing Healthy Team Practices

[1.25 hours] Research, Design and Prototyping

[15 min] Snack and Rest Break

[30 min] Introduction to CAD

12

Equipment the Workshop Uses

Research in a team.

13

Workshop Agenda (Day 2) (Work in a team)

CAD and Machinery

[30 min] Continuation with Intro to CAD

[45 min] CAD for Project Work

[15 min] Snack and Rest Break

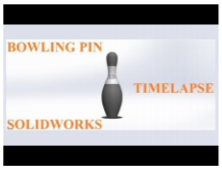
[30 min] Makerspace Safety and Use

[1 hour] Finish CAD Designs

14

Equipment the Workshop Uses

Work on the design using CAD in a team.



15

Workshop Agenda (Day 3) (Work individually)

Assembly and Reflection/Discussion

[30 min] Tool Safety and Use

[1.5 hours] Assembly

[1 hour] Reflection/Discussion/Personalization

16

Equipment the Workshop Uses

Staff will laser cut the design

Personalize the design individually

17

Survey: Workshop Agenda Feedback

https://forms.gle/q2fhXiC4hLJr6KmC8

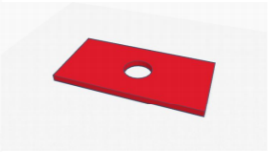
18

Break 2-3 mins

19

Intro to CAD: Building Parts with TinkerCAD

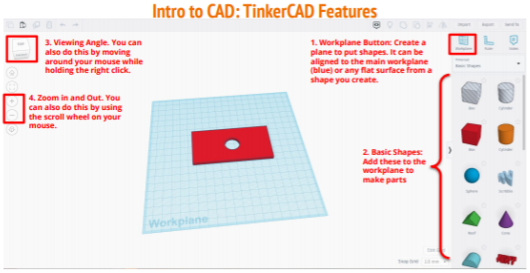
Advanced Birdhouse



Today's Goal

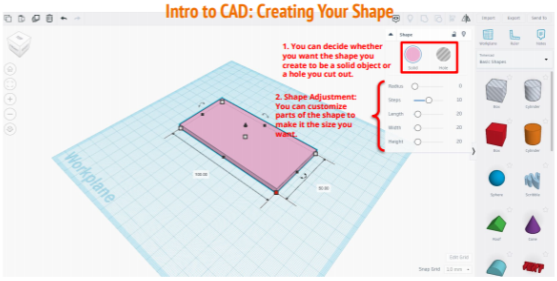
20

Intro to CAD: TinkerCAD Features



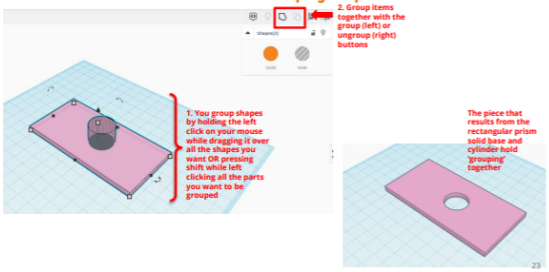
21

Intro to CAD: Creating Your Shape



22

Intro to CAD: Grouping Shapes



23

Now Let's Try It Together

https://www.tinkercad.com/

24

Intro to CAD: Feedback

- Did the slides/reference sheet help you to understand CAD? What could have been improved?
- Did the step-by-step direction help you to understand CAD? What could have been improved?
- What is your preferred method of learning new concepts at school?

25

Survey: CAD Feedback

https://forms.gle/q2fhXiC4hLJr6KmC8

26

Thank You!

For any future questions, concerns or feedback, send us an email through our alias: **gr-IQPMSG@wpi.edu**

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F.4: Focus Group 3 Survey

Focus Group 3 Survey Form

* Required

Workshop: Create Your Own Birdhouse

Learn about the benefits of birdhouses.
Design pieces of the house with a team using CAD.
Create the pieces using a laser cutter.
Assemble the house using tools.
Express yourself with painting.

Workshop Agenda: What were your impressions of the flow of the workshop on a day-to-day basis? Does it make sense? *

Your answer

Workshop Agenda: What is your favorite part about the birdhouse workshop? *

Your answer

Workshop Agenda: What can we improve on the birdhouse workshop? *

Your answer

Workshop Agenda: The workshop consists of team research/design/prototyping and assembly, and individual CAD work (with team support). Does this structure make sense? How can we improve it? Are there any concerns about it?

Your answer

Workshop Agenda: Any recommendations to making the workshop more fun? How can we further personalize it to make engineering fun? *

Your answer

Intro to CAD

Intro to CAD: Did the slides/reference sheet help you to understand CAD? What could have been improved? *

Your answer

Intro to CAD: Did the step-by-step direction help you to understand CAD? What could have been improved? *

Your answer

Intro to CAD: What is your preferred method of learning new concepts at school? *

Your answer

Overall comments about the whole workshop you helped us plan? *

Your answer

Appendix G: Workshop Final Deliverables

G.1: Workshop Agenda

This agenda is a description of the flow of a 4-day workshop with ~3.5 hours each day. Preceding each agenda item is an estimated time for it.

Day 1: Introduction with Research, Design and Prototyping

1. [15 min] Introduce Project: Talk about what project we are doing and why we are doing it. Give an agenda on what students will be going through. Make sure to address the following:
    a. Career Connection: Introduce students to mechanical engineering and some of the focuses (design and manufacturing). Here, discuss how mechanical engineers use CAD to create parts in the real-world and include examples.
    b. Real-World Applications: Mention that they will be using mechanical engineering skills to create their birdhouse. (CAD for building the walls and machinery to manufacture the parts).
2. [15 min] Developing Healthy Team Practices: Put students into random pre-assigned groups of three and have them get to know each other through creating Team Goals/Rules and Ice Breakers.[1]
3. [1 hour] Research: Teams will work together to generate research questions to help them understand the importance of birdhouses, and what factors are important to creating them, then use the internet to look for answers.[2]
    a. Questions to consider are the following: What are birdhouses used for? What makes a birdhouse good (e.g. size, shape, features)? What are birdhouses good for? How can they improve the quality of life (e.g. ecosystem, mental health)?
4. [30 min] Snack and Rest Break
5. [30 min] Design: Have teams sketch out at least two ideas for prototypes based on what they found about what features make a birdhouse good. Then between those, discuss the pros and cons for each design, and choose one that best fits what the team wants to accomplish.[3]
6. [1 hour] Prototyping: Have students create a prototype for the design they chose using cardboard or foam materials.[4] Teams will focus on creating measurements for their pieces, so they will fit together since that will help a lot when doing the CAD and assembly.

Total time = 3.5 hours

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[1] It would be helpful to have a list of questions for teams to go over for Team Goals/Rules as well as icebreakers prepared..

[2] It would be a good idea to split up the time so that the first 30 min is used to generate questions and the second half to conduct research.

[3] When choosing pros and cons, students can consider if they are appealing to a specific species.

[4] Ideally, the materials should be about the same thickness as the materials used, but if not possible, have students consider what they can do to overcome that during prototyping.

Day 2: Introduction to CAD

1. [1 hour] Introduction to CAD: Help students set up accounts to make CAD. Teach students how to open a project and make shapes on a workspace plus simple skills they will need like extruding surfaces and extrusion cuts.[5]

Total time = 1 hour

Day 3: CAD and Machinery

1. [30 min] Continuation with Introduction to CAD: Lecturers will go over the concepts mentioned yesterday and elaborate on how they can be customized for students to design their own piece.
2. [30 min] CAD for Project Work: Students will work in their groups (with the help of assistants) to work on their CAD pieces based on the prototypes that were designed on Day 1.
3. [30 min] Makerspace Safety and Use: A staff member will give students safety instruction and training on how to use the makerspace of choice with an example piece. Use this as an opportunity to continue to discuss mechanical engineering and the manufacturing side of it.[6]
4. [30 min] Snack and Rest Break
5. [1.5 hour] Finish CAD designs: Students will do their CAD until completion of the design. Once the design is finished, the students will get their design "proofread" by an assistant to make sure it is feasible. Then they will work with a helper to put all the pieces on one workspace to be laser cut.[7,8]

Total time = 3.5 hours

Day 4: Assembly and Reflection/Discussion

- [45 min] Tool Safety and Use: A staff member will give students safety instruction and training on how to use different tools typically used for assembling pieces (e.g. drills, handheld tools, glue).
- [1.5 hour] Assembly: Students will work with assistants and each other to help assemble their birdhouses.[9,10]

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[5] Students won't be expected to know all of this by the next day. This is a first step to giving them exposure since learning one skill over multiple days is helpful for the brain to process it.
[6] This also serves as a break from CAD since it could be frustrating for students to do too much at one time.
[7] Each piece will be laser cut multiple times so each student can take a birdhouse home.
[8] Parts should be cut by staff. Students can see how their part will look on the laser machine in the beginning, but it would be disengaging to have them watching for the whole duration of the time. If needed, Day 3 and Day 4 can have a day break inbetween to get all the pieces cut out. Maybe the students will have a chance to look at it if the day break is used.
[9] Even if students get individual birdhouses, they should still work together to assemble, so that all members of the team finish at the same time.
[10] After teams finish assembly, they should take a quick break. If they finish early, teams can start the reflection and discussion portion.

- [1 hour] Reflection/Discussion: Teams will discuss their projects and learn how to give each other feedback. They will also have a chance to hang out and have fun while painting their birdhouses.[11]

Total time = 3.25 hours

G.2: Materials List

- Prototyping Materials: Cardboard, foam, measuring tape, permanent markers, box cutter/exacto knife.
- Final Product Materials: Baltic Birch Plywood, wood glue, safety glasses, masks, dowels.
- Creativity Materials: markers, latex-based or water/outdoor proof paint, sharpies, brushes, gloves, aprons.

G.3: Overall Learning Outcomes

1. Learn about the design and manufacturing fields of Mechanical Engineering.
2. Learn how to develop a project through phases of ideation, prototyping and completion using the engineering design process.
3. Learn how to translate a prototype to CAD on SolidWorks.
4. Learn communication and listening skills by working in teams.

G.4: Recommended Space

Foisie or Washburn for laser cutters, Foisie for bench space to assemble birdhouses, and Higgins Lab for the computer room.

[11] Paints should be outdoor safe if possible.