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Attributing Factors to the Gender Gap in STEM Education and a Corrective Measure to Mitigate the Shortage at a Local Level

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Attributing Factors to the Gender Gap in STEM Education and a Corrective Measure to Mitigate the Shortage at a Local Level

by

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Dedication

This paper is dedicated to my wife and children who have continued to support my efforts of continuing education even though it has brought disruption into their own lives.

Acknowledgments

I would like to thank the University of Texas at Austin professors who guided my learning and understanding of both the practical and theoretical aspects of STEM education. Your influence has made me a better teacher and will benefit my instruction to students for years to come. A special thank you to my advisors Dr. Reigle-Crumb and Dr. Marshall for opening my eyes to the existing research on this topic and giving me extremely timely feedback and suggestions for improvement.

Attributing Factors to the Gender Gap in STEM Education and a Corrective Measure to Mitigate the Shortage at a Local Level

by

James Andrew Hahm, M.A.

The University of Texas at Austin, 2015

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Women continue to be underrepresented in science, technology, engineering, and mathematical fields at the national level. At a local high school level, male enrollment in pre-engineering classes continues to outpace female enrollment. Based on a review of current literature some key contributing factors are: a lack of role models for females considering STEM, lack of confidence in one's STEM abilities, ingrained stereotypical views of society shaping female identity, and a lack of understanding of the societal benefit STEM careers can have on the greater population. To address these concerns, a summer camp was created for middle school-aged females. Though the camp will not solve the national problem, it will be a positive step in addressing the current trends at the local level. This camp will also provide a means to conduct future research with participants, parents, and camp assistants.

Table of Contents

List of Figures

The Problem

The 2014 jobs data shared by the U.S. Bureau of Labor and Statistics continues to show women are underrepresented in certain science, technology, engineering, and mathematics (STEM) fields. Women comprised only 15.4% of the labor market in the category labeled *Architecture and Engineering Occupations* in 2014. In the subcategory of *Mechanical Engineering,* women comprised less than 9% of the work force. The highest percentage of women working in the *Architecture and Engineering Occupations* category was the subcategory of *Architects, Except Naval*, which was slightly higher than 25% (The U.S. Bureau of Labor and Statistics).

Recent enrollment data at Wisconsin Lutheran High School located in Milwaukee, Wisconsin, within classes specifically designed to promote engineering and STEM fields, show that female membership averaged roughly 11% for the last two school years ending in 2014 and 2015. The last two years were an improvement from 6% female enrollment in the school year ending in 2013. Though the STEM program focusing on engineering is relatively new for the school, having just completed its fifth school, female enrollment numbers are at or below the nationwide averages for females working in engineering fields.

The STEM and engineering curriculum currently being used at the high school is a curriculum that has been adopted from an outside source and requires teachers to adhere rather strictly to this curriculum. Guidance to the students has continued to improve as familiarity with the curriculum is gained by both teachers and school counselors. Yet the problem remains; there is a large gender gap in enrollment in these engineering-based classes. This local gender gap is indicative of the national gender gap in engineering and STEM related fields. Continued guidance emphasis will be placed on tweaking the promotion of such classes to females, but there is opportunity to address the problem using the high school's existing resources for an additional solution. The goal of this paper to create a researched-based STEM camp that will provide an earlier entry point into engineering and STEM classes for female students within the given resources and expertise of the school. Current research will be used to gain an understanding of the gender gap problem in STEM-related fields. The research will then dictate areas of emphasis to be offered through the camp. Research will provide a deeper understanding of what may or may not influence an adolescent girl to consider a pre-STEM college path that leads to a college and career path in STEM.

Literary Review

How does one know what career to pursue? One of the concepts that helps guide people through life, as they make decisions, is called identity. According to Schwartz, Erikson's "identity" helps people "anchor" (Schwartz, 2005, p.294) themselves in a multitude of future possibilities. Identity helps guide a person to find her/his place in a vast open world of possibilities. A clear identity can have a very positive impact on what a person is to accomplish during her/his life; on the contrary, those that lack a clear identity seem to struggle (Schwartz, 2005, p. 294).

To gain understanding in how identity influences one's choice in STEM, Dinella, Fulcher, and Weisgram's ((Dinella et al, 2014) published work titled "*Sex-Typed Personality Traits and Gender Identity as Predictors of Young Adults' Career Interests*" helps to illuminate the role identity plays in shaping a girl's decision-making process. The authors cited work from the National Academy of Sciences dating back to 2006, along with the information from the Bureau of Labor and Statistics from 2011, which state that there is a "significant increase in the number of women achieving degrees in science and engineering," and yet "few women hold occupations in these fields" (Dinella et al, 2014, p. 493.) Dinella et al (2014) tested whether a person's self-perceived masculinity or femininity would have an influence on career choices. In their experience they discovered that "the more individuals felt they were typical of their gender group, the more interested they were in traditional careers and the less interested they were in non-traditional careers"(Dinella et al, 2014, p. 502). In other words, if a young girl grew into adulthood feeling she was a typical girl she would consider choosing a traditionally-accepted career for a girl to pursue (Dinella et al, 2014, p. 502). This might be the reason that girls still continue to pursue nursing as a career choice more so than boys and, conversely, why boys tend to express interest in engineering more than girls. In their publication Dinella et al. (2014) noted that women felt more pressure to conform to the traditional roles. This pressure, they felt, had undue consequences for women such as leading to lower-paying careers (Dinella et al., 2014, p. 502-503). However, the authors did not feel that if a girl experienced less pressure to conform, she would be open to pursuing additional careers typically filled by men

(Dinella et al., 2014, p. 502). It appears that, whether male or female, there is still a strong pressure to choose traditional career roles. This research is helpful in trying to discover what may or may not increase the number of women in STEM. Traditional societal roles are challenging to break. It is evident from the authors' findings, that the more stereotypical a girl is, the more difficult it may be to get her to consider a career choice that has not traditionally been promoted as a career for girls to pursue (Dinella et al., 2014, p. 502).

Shelley Correll (2001) studied gender differences from a different angle. Looking at math scores, she argued that "perceptions of competence" (Correll, 2001, p. 1692) among genders were of great value. In other words, it was how well a student thought she/he did at math, not just how well she/he actually did in math that affected her/his perception of identity or future success (Correll, 2001, p. 1692). She noted that it was important to study the "perceptions" early and recommended that the high school level would be appropriate (Correll, 2001, p. 1693). Her premise and finding were that "males will overestimate and females will underestimate their own mathematical ability" (Correll, 2001, p.8, 1724). This is an issue because she quotes work done by Sells in 1973 and Dossey et al. in 1988 in which math acts like a "critical filter" blocking women from STEM-like careers (Correll, 2001, p. 1694). Building on earlier work Correll "estimated a logistic regression model of the effects of the calculus enrollment variable" and found that "females who enrolled in high school calculus are 3.22 times more likely to choose a quantitative major than females who did not take calculus" (Correll, 2001, p. 1722-1723). If Correll is correct in stating that girls start with a poorer perception of their math abilities than do boys, even though they have similar scores, her findings support getting girls into higher level math classes early to build an accurate mathematical identity (Correll, 2001, p. 1722-1723). Likewise, a study done by Ascherbacher, Gilmartin, and Li noted a similar effect on girls' grades in science and the girls' interest in science as a career: "The correlation between science class grade and career interest is stronger among girls than among boys" (Ascherbacher et al., 2006, p. 190.) Correll and Ascherbacher et al. indicated that girls' self-concept of their abilities plays a large role in what they are willing to pursue. Furthermore, Corell (2001) indicates that technical instruction, like that provided in calculus, positively influences a girl's future educational path.

Jo Boaler (2002) studied differences in gender and ability in mathematics. Boaler described a study she had published in 1997 working with boys and girls starting when they were thirteen and ending when they were sixteen. Boaler researched two separate schools and studied their math grades (Boaler, 2002, p. 133). One school was a traditional school with traditional teaching methods, and the other school was a project-based school. During the study Boaler noticed “the girls at the project-based school, Phoenix Park, were always significantly more positive and confident than the girls following a procedural approach at Amber Hill” (Boaler, 2002, p. 133). She also noted that at the school “where an open-ended, project-based approach was employed, there were no gender differences between girls and boys at any level” (Boaler, 2002, p. 133). Boaler goes on to explain that perhaps it is the teaching method that is causing the differences in mathematics success, not the gender (Boaler, 2002, p. 135). If Boaler is correct, ensuring students participate in open-ended projects may be part of the answer to reducing the gender gap in pre-engineering and STEM classes.

Within the school day, there are those who have attempted to change the stereotypes regarding STEM careers and explain the work that is needed to succeed in those careers. Christina Scherrer ran one such study that took a group of graduate students, mostly comprised of underrepresented populations, to local schools to promote the notion that “engineers help to make a better world” (Scherrer, 2013, p. 39). Through the use of surveys, used both before and after the graduate students’ presentations, the research team observed one especially notable change: “The percentage of students choosing “help people” as a reason to enter engineering increased from 30% to 60%” (Scherrer, 2013, p. 41). Scherrer suggests that “the human impact potential of engineering is a more convincing argument for women and other underrepresented groups than for men” (Scherrer, 2013, p. 42). According to Scherrer, showing people the human side of engineering and STEM can have a positive impact on decreasing the “underrepresented groups” numbers in these fields. Perhaps, too often, the idea that engineers solve problems in people’s lives is hidden by the sophistication of their work.

Kekelis, Ancheta, and Heber (2005) made recommendations from studying activities that took place in after-school activities at Techbridge in Oakland, California. Enrolling girls in activities that the girls themselves found appealing, the researchers created an after-school program to study the effects of this program on the girls' perceptions of technology-based careers (Kekelis et al., 2005, p. 99). After being surprised to discover that positive after-school experiences did not translate into girls expressing an increased interest in technology, the team focused their efforts on identifying a "number of hurdles in the educational pipeline for technology careers" (Kekelis et al., 2005, p. 100). Through interviews, the team found that the girls themselves had deep and false stereotypes of what it means to be in a technology field and that these false stereotypes were creating limitations for the students (Kekelis et al., 2005, p. 101). If girls knew that they would like to pursue a career in technology, they often had no idea how to follow such a career path (Kekelis et al., 2005, p. 101.) In other words, they had no idea how the STEM pipeline flowed or what was needed to be in the STEM pipeline (Kekelis et al., 2005, p.102). Kekelis et al. (2005) found that the girls were further disadvantaged by lack of guidance from parents. This lack of guidance spanned cultures and educational backgrounds. That is, parents in general, were not providing specific career or college advice to their children (Kekelis et al., 2005, p. 105). If, however, a girl was interested in a technology field "without knowing about specific career options in technology or being acquainted with anyone who could serve as a role model, it may be hard for the girl to maintain her interest in the field" (Kekelis et al., 2005, p. 101.) From the work of Kekelis et al. (2005), it is apparent that even though girls are active in STEM programs it is still necessary that the girls have access to good guidance. Participating in STEM activities is simply not enough; girls need to be shown explicitly which careers might fit their interests and abilities and how to attain such a career.

In a study done by Lee and Sriraman (2012), the parents were cited as having a negative effect on one gifted girl's mathematics study and ability to pursue a career in the sciences. These parents, with advanced degrees, despite their daughter being enrolled in gifted programs, thought careers in science were "difficult for women" and later discouraged their daughter from pursuing such a career (Lee and Sriraman, 2012, p. 6). To compound the problem, the researchers brought to light, once again, the shortage of mentors available to the girls (Lee and Sriraman, 2012, p. 10). Finally the fact that the girls were in a program for gifted children might have actually led them to feel inadequate in the very field in which they showed potential. When reflecting to the interviewer about the time invested in solving math problems, one girl developed the idea that she was not as good at math because her math work was difficult and therefore she must not be really good if she had to struggle (Lee and Sriraman, 2012, p. 7). Ultimately the researchers discovered that the girls they interviewed "had been concerned about their future careers from elementary school and perceived gender inequality since then" (Lee and Sriraman, 2012, p. 12). Lee and Sriraman (2012) comment that more guidance is needed to help girls break the "gender inequality" (Lee and Sriraman, 2012, p. 12). Lee and Sririaman's study (2012) serves as an encouragement to those who provide guidance to girls; girls should be guided to understand that struggle does not equal inadequacy.

Influences on Camp Design

Though the school has fully embraced a curriculum that gives high school students the opportunity to experience STEM education, there are a few negatives that may provide difficulty in positively affecting the gender gap. The school currently uses a purchased STEM curriculum that requires strict adherence to the curriculum through signed agreements and student testing. Though the students benefit from the adopted curriculum and mandatory testing in such areas as articulated college credit and current technology agreements, there is little opportunity for curriculum adjustment or enhancement. Furthermore, the time commitment for a pre-engineering class is large on the student's part; each class requires enrollment in a year-long high school class. As the list of mandatory high school graduation credits continues to grow, elective openings in a student's schedule become fewer and more highly coveted. In this school's example, students are limited to approximately two credits to share among electives each school year in such areas as engineering, foreign language, business, art, or music. In addition these are high school classes, which at best have the limited time frame of four years to encourage students to pursue STEM-related classes and fields.

It then becomes beneficial to find an avenue that will promote engineering and STEM concepts to girls earlier than the level the school formally has access to, namely, high school students. The ability to influence the girls earlier will expand the time the high school can provide guidance to the students. A summer camp was chosen as the avenue to apply the literary research and address the local gender gap. A summer camp will allow the flexibility to apply the literary research that the formal curriculum will not provide while at the same time fitting into an existing structure of camps that the high school currently runs. The structure, called "Viking Explorers", is a summer day camp program offered by the high school to middle school students. The majority of camps are geared towards athletics; however, there are some camps that promote a slightly more academic nature such as robotics or theatre camps. These camps have helped to make a smooth transition for students from middle school into high school athletics or arts and may also provide a smooth transition for students into high school STEM opportunities. A summer camp will further extend the time frame the school has to influence the students while also providing an available opportunity to put research into practice.

Though a STEM type camp could be created for middle school students that was fun, enjoyable, and educational, it is important that the research have significant influence on aspects of the camp design. Special attention was given to developing activities that would be both STEM in nature and simultaneously allow the research to be put into practice. Areas of research that will be emphasized in the camp include building the girls' confidence in their ability to handle the nature of engineering work, educating parents/guardians regarding the girls' abilities and interests, and connect the girls to role models that can provide firsthand experience to the STEM pipeline.

Activities were also developed around the school's current resources in both personnel and equipment. A full-time teacher is available to start the camp, and the high school engineering classes provide a source for girls already interested in STEM to be both peers and role models to the campers. Current technology of both software and hardware, along with newly constructed engineering facilities, are also available for camp use at the school.

Through the work of Lee and Sriraman (2012) and the research of Kekelis et al. (2005), it became evident that parents needed to be part of the solution in creating a positive STEM identity for middle-school girls. During the camp, at the end of each day, there is time for the parents/guardians to arrive and observe their daughters working on a STEM project. There is also time for the participants to explain to the parents/guardians the day's activities and what they learned from those activities. The goal is to demystify a STEM experience for both the parents and children and leave both with the impression that this could be a valid current and future identity for the girls. It is important that the camp provide this daily avenue for parents/guardians to see firsthand the abilities their daughters have, or STEM-related curiosity the girls show interest in developing.

On days two and five of the camp there is included an element which is influenced by the research of Scherrer (2013), who explained that "the human impact potential of engineering is a more convincing argument for women and other underrepresented groups than for men" (Scherrer, 203, p. 42). The pendant project is meant to put a human side to the design process by giving the participants the opportunity to affect someone's feelings or attitudes with a gift designed with them in mind. Likewise, day five gives the participants the opportunity to weld something of their choosing that could be created with someone else in mind.

Experience with a design process, along with technology, math, and science concepts are meant to give the participants the opportunity to create a positive identity and self-confidence within one or more of these areas. Schwartz (2005) made it clear that identity helps "anchor" people and provides for future success (Schwartz, 2005, p. 294). It was therefore important that the camp give the participants the ability to experience different anchors that might help guide their future (Schwartz, 2005, p.294). The camp does not focus on any one of the ideas all week but rather weaves a design process and elements of it throughout the week. Technology and computer skills are taught to allow participants the opportunity to solve open-ended problems. Science and math skills are used in context and in a relevant fashion to help participants see how these tools could be part of their "anchor". Science and math skills are also used in the camp to increase their "perceptions of competence", as Correl (2001) would suggest. (Correl, 2001). The camp will give opportunities for campers to build mathematical scientific confidence. A large breadth of offerings is experienced, from manufacturing to engineering, to help participants explore and create their unique STEM identity.

Christina Scherrer's (2013) work had further influence on the camp in a subtle fashion. In her research she used a team of graduate students, who were from underrepresented STEM populations, as the group to present and to do research within a school (Scherrer, 2013, p. 39). In this proposed camp there will be two to three female assistants that will help with the diverse technology, math, and science needs. That is, the intent is to have the assistants help with more than such matters as camp supplies or school building logistics, but also to give the assistants the opportunity to be STEM role models on a one-to-one basis. To begin with, these STEM assistants would first be high school females that are also interested in STEM. A longer-range goal would be that the assistants grow in their experience and that perhaps, in a year or two, when they are in college, the assistants would become the primary instructors, and the current instructor could become the assistant. Girls leading the camp would also help fulfill the vast need for mentors that is described by Kekelis et al. (2005, p. 101). "Without knowing about specific career options in technology or being acquainted with anyone who could serve as a role model, it may be hard for the girl to maintain her interest in the field" (Kekelis et al, 2005, p. 101). In addition, two lunch time guest speakers are planned to introduce the participants to women already working in STEM fields.

Kekelis et al (2005) continue to influence the camp design with the previously-mentioned quote of, "without knowing about specific career options" (Kekelis et al., 2005, p. 101). The camp is intended to introduce the students to engineering through a design process. The camp purposely takes a different path by using relevant math and science to introduce two manufacturing/technical fields not often promoted to females: welding and computer numerically controlled (CNC) programming. Though robotics camps may be used to promote programming and problem solving in STEM, this opportunity was designed to use the resources available at the high school where the camp is located, while avoiding a duplication of a current robotics camp held at the school which is open to both boys and girls.

The research makes it clear that gender stereotypes continue to be a strong influence on identity development and that if females tend to think of themselves as traditional females they will continue to gravitate toward careers that are traditionally accepted by society as suitable for females (Dinella et al., 2014, p. 502). Lee and Sriraman (2012) stated that gender inequity was observed as early as the elementary school (Lee and Sriraman, 2012, p. 12). This camp is designed as a "girls only" camp to provide an intensive opportunity for an older group, middle-school girls, to create an identity that is free of gender inequity. It is the goal of this camp, by giving the participants the opportunity to succeed within this particular STEM experience that they will be free from the stereotypes they may encounter in a normal school setting. At first a girls-only camp may seem unique to the high school, but there is already separation of genders in sports camps held at the school during the summer. Therefore it would not be inappropriate to have an academic-based camp that is gender specific, similar to existing sports camps. An all-girl STEM camp also acknowledges the societal inequality between males and females and publically tries to correct this disparity.

Camp

The camp will be advertised in the school's publication called "*Viking Explorers*" in which all summer academic and athletic camps are promoted. This publication is distributed to all schools that serve as feeder schools to the high school and can be found on the high school's website. If early enrollment is low, there is an established relationship with the feeder school teachers and administrators, who would be able to promote the camp in their individual classrooms and schools if they were asked to do so.

The camp consists of five days of activities. Days one and two of the camp allow the participants to use an engineering design process to make 3D-printed custom parts. In this case they will make custom-designed necklace beads and a pendant. Day three relies and expands on the student's science background to explain how electrical and mechanical devices that surround them operate. Day four gives the students the opportunity to use math skills to program a CNC machine. Day five culminates the participants' week by giving the participants the opportunity to apply simple electrical circuit knowledge to the hands-on activity of welding.

Parents/guardians are important to the success in encouraging the participants. The camp provides an opportunity for parents/guardians to be part of their child's STEM experiences. The last half hour of each day is scheduled for participants to explain their new understandings to their parents/guardians. The instructor and camp assistants will circulate throughout the camp classroom to engage both adults and children in conversations pertinent to the day's activities and their child's accomplishment in those activities. The instructor and camp assistants will make an extra effort to celebrate the participants' accomplishments that are STEM-related in order to provide specific positive feedback.

Day one of the camp is designed to give the participants the context to think about and solve an open-ended problem using the techniques of an engineer. A problem-solving design process is used to frame a problem, and participants will use 3D software and 3D printing technologies to aid in the design and creation of a prototype.   These two tools, a design process and current technology, have been chosen to introduce the participants to the thought processes and tools of an engineer. With these two tools, the participants will become more informed as to the nature of the work performed by engineers. Once participants see and experience how engineers work, they will be better informed to evolve their identity to include engineer as a possible career option.

Day two provides a review of the first day's material to build the participants' confidence in working and thinking like an engineer. In addition to a review, day two provides a target or customer for the participants' creation. Day two makes use of a "customer" to help the participants understand the human side of creating and inventing products; that is, products are designed with the benefit of people in mind. Participants will once again use the design process and current technology to make their unique designs.

On day three participants will use their existing scientific and technological knowledge to predict how the inner workings of everyday items function. Participants will begin with terminology and illustrations with which they are already comfortable. Slowly, but intentionally, the instructor will guide the students to incorporate common scientific and technological terminology that the students have experienced in previous science classes. A major goal of this day is to help the participants see appreciate that science knowledge is put into practice all around them.

On day four engineering, mathematical knowledge, and computer programming skills will be combined to build confidence in these areas of STEM. Participants will use the Cartesian coordinate system of graphing locations to drive a computer numerically controlled (CNC) machine. This will expose the participants to a new technological tool that can be used to create unique designs. Reverse engineering techniques will be used to improve an existing design.

STEM concepts will continue to be emphasized while finishing the camp on day five. On this day science knowledge of electricity, mathematical measuring skills, and engineering design will be emphasized while introducing the participants to the technically-related field of welding. Starting with the familiar concept of gluing paper, participants will move through the use of hot glue and paper into the realm of the unknown by applying the hot glue techniques to welding.

Similar to previous days, a major goal is to leave the participants with an “I can do this” and “I would study this in school” attitude to build confidence in choosing their future school and career path.

Next Steps

This camp provides an opportunity to implement the research of others in understanding the gender gap while also providing a practical implementation plan to close the gender gap at a local level. The camp lends itself to further research in studying the gender gap topic surrounding STEM. For example, the works of Lee and Sriraman (2012) and the work of Kekelis et al. (2005) cited that parents play an important role in the shaping of the child's identity. During the schedule of the last half hour of camp each day, parents are able to be part of their child's experience. Pre-camp and post-camp surveys and/or interviews of the parents could lead to better understandings concerning the influence parents/guardians have on a girl's identity and willingness to choose the pipeline leading to STEM.

The school may set a future goal to raise the female population in STEM classes to "x" level within so many years based on the camp and other educational efforts such as improved guidance counseling. The camp encourages the school to make connections to past graduates who are working in STEM fields in order to serve as role models during the lunch time presentations. These connections may grow stronger and cement a long-term relationship between the school and these graduates. The camp provides a channel for graduates to give back to their school and community in a very specific way, by mentoring the next generation of females considering STEM careers.

The assistants involved in the camp could also be tracked long-term. What were their attitudes towards STEM before and after the camp? Can participation at the teaching level of a camp provide experiences that will secure a STEM future foundation for the assistants? Though they have shown early interest in STEM, could this camp help or hurt their efforts to continue in the STEM pipeline?

Finally, the campers themselves could be tracked, especially by the high school, as they choose classes during high school and select a college major upon graduation. Can meaningful math and science concepts integrated into a STEM camp provide positive long-term confidence in the camp participants regarding their abilities to participate in STEM pathways? In the short term pre-camp and post-camp surveys similar to Scherrer's (2013) could be given to see how the camp influenced the participants' identity in the near future.

Appendix

Camp Details

Design and Make, Day 1

Monday, Day 1

The day begins with a flexible half hour arrival time that is to accommodate those families that may need to drop off participants earlier due to work or other schedule conflicts. The half hour arrival time is also designed to provide parents/guardians and participants with a bit of a relaxed schedule. If participants arrive closer to the 8:00 time they will be encouraged to get to know the building and fellow classmates until the formal introductions begin at 8:40.

8:30

To begin with a professional tone, appropriate for 6-8th graders, engineering design notebooks will be handed out at 8:30. Engineering notebooks can be purchased from BookFactory, bookfactory.com, for about $16 each. Participants will be encouraged to put their names in them. They will be instructed as to the purpose of the engineering notebook, which is used to document their accomplishments throughout the week. The notebooks will have adequate pages to be used during the week but also have enough pages left over that a student may fill in their own designs once the week-long camp is over. On page one of the notebook, participants will copy a design process that will be displayed within the classroom.

8:40

A group photo will be taken and placed into each participant's notebook. The lead teacher and assistants will model an introduction by stating their names and expressing two hobbies or interests that they each have. The participants will be encouraged to write down the names of their instructors and their interests on the engineering page that contains the group photo. The participants will then introduce themselves, during which time the students will be encouraged to take notes in their notebooks about their fellow classmates' hobbies and interests. The time will end with the instructors reciting everyone's name and giving those participants that are interested, the chance to also recite names.

9:00

The main purpose of the next hour is to give the students a chance to learn some basic commands in Autodesk Inventor, the software that is going to be used to create the three dimensional drawings. Though the software chosen is Autodesk Inventor, other 3D design platforms could be used. Inventor is chosen simply because it is the current software the school utilizes. The instructor will start with the assumption that no student has ever opened or used this or any other 3D software. Instruction will begin by giving the students a login name and password that allows them access to the school computers. Once students are logged in, the instructor will demonstrate how the software is opened. Once the software is opened, the instructor will guide the students into making what Inventor calls a "part" file. In the sketch mode of the part file, the participants will be shown how to create geometric shapes such as circles, squares, lines, and polygons as demonstrated in figure 1. Participants will be shown how to use the "undo" button and how to delete a sketch they don't intend to use. Once each student feels comfortable creating custom shapes, the instructor will explain that these shapes can be dimensioned to a specific size. Although the instructor will provides examples of dimensioned shapes, participants will also be encouraged to create their own shapes. When all of the participants feel comfortable with creating shapes and using the dimension tool, the instructor will show the participants how to extrude those shapes into three-dimensional objects. Figure 2 shows the result of an extrusion in addition to using the hole and chamfer commands. The filet command will also be demonstrated to make curved surfaces.   It should be noted that the primary instructor will explain the software while the two assistants will provide assistance to any participants that may struggle finding the right computer program button or have inadvertently mouse-clicked their way into a problem.

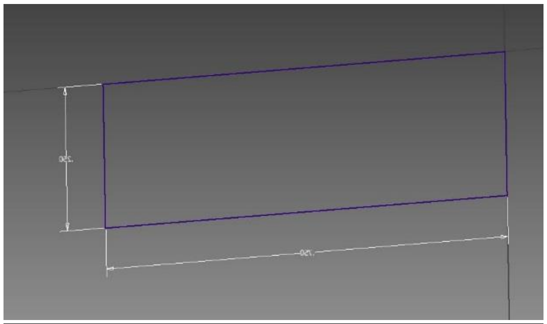

FIGURE 1 INVENTOR SKETCH

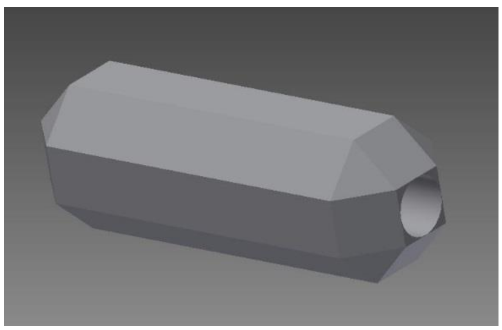

FIGURE 2 EXTRUDED, CHAMFER, HOLE COMMANDS USED

10:00

A tour will be given by the assistants to show the nearest bathrooms and drinking fountain locations. When participants arrive back in the classroom, they will be shown the 3D printer that is in the classroom and, while watching it run, receive a simple explanation on how the printer works. This particular printer is a *Dimension sst 1200es*, made by Stratasys, capable of prints as large as ten inches cubed. Within the explanation of the 3D printer will be included the concept that 3D printing is an additive manufacturing process as opposed to a subtractive process commonly used in the manufacturing of goods.

10:15

An engineering design process will be introduced to the students by mean of a collective class invention. Students will be asked, “What do we want to invent in the next 30 minutes?” When the class agrees on a particular object, machine, or concept through class discussion the steps of the chosen design process will be applied to the class “invention” or problem needing solving. The steps will be abbreviated in order to show the participants the entire design process that they will be using shortly and throughout the week in various forms. It is also recommended that the major steps of a chosen design process be placed on a bulletin board or poster for the students to refer to as needed. Participants will be reminded that on page one of their engineering notebooks is the engineering design process that they will be following.

10:45

The instructor will guide the participants through the steps of an engineering design process so that each participant can create her own beaded design. The intent is that each child will have the opportunity to create and 3D print their unique design. An engineering design process is used simply to give the participants a structure for their creativity while also teaching them how an engineer or STEM professional might solve an open-ended problem. Students and instructors will talk about criteria, constraints, and/or limits that might help to guide the invention of a new bead design. For example, the group should discuss the optimal range for the minimum and maximum size of a bead. The group should also determine an accepted hole size within the bead that would allow the beads to be strung together by string. Participants will be encouraged to draw various possible bead designs and share their designs with others as they explore possibilities. Participants will be led throughout the building by the assistants to ask building staff what they think would make a good bead for a beaded necklace. Participants will be given permission to call a friend or relative and ask the same question. Participants will also be allowed to use the internet to search for possible ideas.

Students will be encouraged to draw various designs in their engineering notebooks. The students will be welcome to create several drawings with small variations to the design or simply explore multiple designs that are uniquely different. For example, they may create a bead that is based on a square, triangle, or even diamond-shaped foundation.

The participants will be asked to pick a few of their designs that they like most and circulate the room to ask others for input on their designs. Finally, the students will rank their top three designs which will become the basis for their models after the lunch break.

12:00

Lunch will be eaten as a group in the engineering room. Lunch time will help participants get to know one another a little more while providing additional time for those that need to finish their final bead designs. Time will be given to use the restrooms and walk outside of the building if weather permits.

12:30

Participants will use the next hour to make their designs on Autodesk Inventor. Some students will use the entire hour to make one design while other students may draw all three of their top designs and may even have more time to draw a fourth or fifth design. The idea is to give the participants the opportunity to create their designs within the limits of the software and the time limits of the camp. The assistants and instructor will circulate through the class helping participants with the 3D tools of Autodesk Inventor. Autodesk Inventor is a computer program used by professional designers, and, while it is relatively easy to pick up the basics of 3D modeling, the hour of instruction will not be enough for everyone's design. In a manner similar to what was modeled by Dr. Allen and Dr. Crawford in UT classes "Design of Machine Systems" and "Engineering Design Methods" giving students "just in time" math skills, these students will be given additional skills as they need them. During the bead design, students will all be instructed in a general understanding of 3D modeling skills but will then be shown further concepts "just in time" as they need them with their unique designs.

1:30

At this time parents or guardians are encouraged to start arriving and watch their participants finish their designs. More importantly, it is also a time in which the participants can share with their parents what they have learned or designed during the first day. The participants will be encouraged to explain what they wrote in their notebooks and why they used those design steps to their parents. They will be encouraged to share with their parents how they decided on their three top designs. The participants will be encouraged to show the new tools they learned about in technology along with using correct geometry terminology to explain their bead designs. Participants will also be encouraged to show parents the 3D printer and explain, from their perspective, how the printer builds solid objects out of seemingly nothing. Parents and students are not required to stay until 2:00, but, depending on the parent's arrival time and how much time the participants use to share their work, the ending time of the camp will vary for each child but mostly end at 2:00. Closer to the 2:00 time the participants' bead designs will be loaded into the 3D printer for printing overnight by the assistants. It is important that the participants not only see the assistants helpful in making class run smoothly, but that participants also see them as masters of the technology so that the assistants may also serve as role models for the participants.

Design and Make, Day 2

Tuesday

8:00

The start of the day spans the 8:00 to 8:30 time to accommodate various arrival times again. Parents and students will be encouraged to look at the beads that were printed overnight. Participants that arrive closer to 8:00 may also have time to use the 3D software to explore new bead designs. The 3D software was purposely taught the first day of camp so that it can be used by the participants that may be grasping the concepts more quickly or who arrive earlier in the morning each day of the camp.

8:30

As the parents begin to leave, the entire group will look at the results of the 3D printed beads. Participants will be encouraged to share observations from the printed beads. Special attention should be given to the capability of detail limited to the 3D printer. Oftentimes students will focus on very fine detail only to realize after a print that the detail was drawn on too small of a scale.

8:40

A general class discussion of possible changes that could be made to improve the bead designs will be held. The beads will be removed from the printed platform and placed in the solution that dissolves the support material. The beads will be ready for participants to take home that evening. Participants will be asked to record any changes they would like to make to their original designs in their notebooks.

9:00

Participants will first be given the chance to review the skills they learned the previous day. They will be given the chance to open a new “part” file and create a simple sketch that could be used to make a bead by extrusion. Participants will then be shown how to use the revolve command. A possible sketch to be revolved is shown in figure 3. Everyone will start this process by creating the same sketch. This sketch will be used to create a revolved shape. Figure 4 is the result of the sketch from figure 3 being revolved around the longest line. Participants will then be shown how to create a plane of geometry on a curved surface that can be used to create a new sketch. This skill will allow participants to create new bead designs. These activities will provide time to review the skills from yesterday while simultaneously creating new 3D modeling skills. It also provides opportunity for new geometry concepts to be explained, like “revolve”.

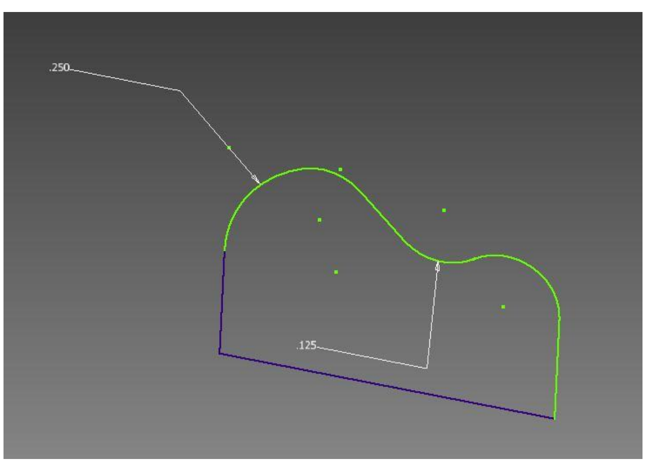

FIGURE 3 SKETCH TO BE REVOLVED

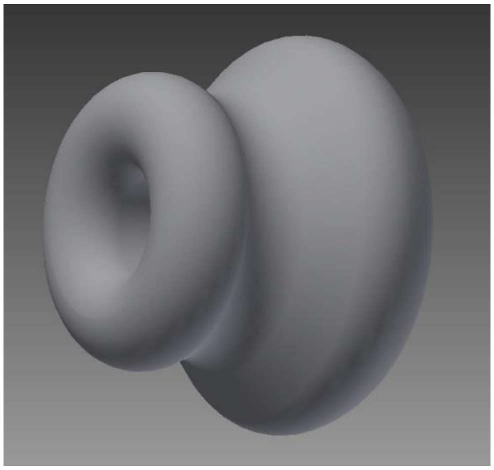

FIGURE 4 RESULT OF REVOLVED SKETCH

9:30

Time will be given to incorporate the new modeling skills into existing bead designs or for creating a new bead that is a result of what the participants have learned from yesterday's and today's experiences. These designs will then be printed for the students to show to their parents at the 1:30 visitor time in the afternoon. The assistants will again be the main 3D printing operators, with participants beginning to be part of the process if time permits.

10:00

Participants will spend this time on a school-wide scavenger hunt designed by the assistants. The purpose for this is to give the students the opportunity to feel more comfortable within the school building. This activity has been incorporated before by the school and has proven to be a positive experience for the participants. This particular scavenger hunt will have a STEM focus. For example, the assistants will be encouraged to design a scavenger hunt that allows the participants to become familiar with the STEM locations in the building. Many of these locations are isolated, and this scavenger hunt will provide the participants a way to become familiar with the STEM locations in the building that are grouped. For instance, the school has a building location dedicated to science instruction; part of the hunt will give the participants the opportunity to become familiar with the science wing of the school. Technology is spread throughout the building, and participants will be given opportunity to find some of those locations. The scavenger hunt will take place with groups of students to also make it a positive peer activity.

10:30

Students will once again use an engineering design process to create a solution to an open-ended problem. This problem will be focused on creating a pendant that can be given to a friend as a way to make their day special. The pendant should be designed to create joy for someone who might not be experiencing joy at that time in their life. Participants will be encouraged to use their life experiences to brainstorm possible pendant designs that they personally would find uplifting during a difficult time. Group discussion will be used to find moments in a person's life that might be in need of encouragement. Participants will be encouraged to create a design that would also benefit them personally in a time when life seems to be more of a struggle. Participants will ultimately print two identical pendants; one for them, and one for them, to give to someone in their life that is in need of encouragement and friendship. Discussion on the minimum and maximum size of a pendant will be discussed as a class. Time will once again be given to gather ideas from multiple sources which could include asking fellow classmates, interviewing people in the building, phone calling family members or friends, or searching the internet. Participants will then create three initial designs to be enhanced in a method taught in Engineer Your World called "C" sketching which was explained in UT classes taught by Dr. Allen and Dr. Crawford in "Design of Machine Systems" and "Engineering Design Methods". This method allows participants to improve their designs through collaboration with their peers. It also allows them to gain ideas from what their peers have designed. Students will then select one design based on peer feedback and create a new sketch of that design. All sketching and documenting will once again be recorded in their engineering notebooks to later show to their parents/guardians.

12:00

The lunch activity today will include a female guest speaker involved in STEM; preferably, but not necessarily, a graduate of the high school and a product of the local community. The guest speaker will be encouraged to share her life story in becoming a STEM professional. The guest speaker will be encouraged to share what she can about her everyday work life. Furthermore, the guest speaker will also be encouraged to share what she feels comfortable about in her personal life. For example, does she have a family and what hobbies does she enjoy? Camp participants will be given opportunities to ask questions of the speaker. In the ideal scenario, the guest speaker will be at her place of employment and the camp participants will be in the school conference room that is set up for teleconferencing. This may allow for easier access to the guest speaker's time along with the possibility of visual images of the guest speaker's place of employment. Camp participants will be encouraged to write down interesting facts that the guest speaker shared during the presentation.

12:30

Participants will now be given time to create their pendants. Figure 5 is an example of one possible pendant design. Once again, with all the participants creating unique designs, the class assistants and leader will continually circulate throughout the classroom to give the participants computer skills as they need them to create their unique design.

FIGURE 5 PENDANT EXAMPLE

1:30

Parents/guardians will once again be given an opportunity to hear their daughter explain what she has learned about STEM today. Participants can share their newly-created bead design along with their pendant design that will be printed overnight. Participants are welcome to show their engineering notebooks along with sharing what they learned from the guest speaker. Departure time will once again vary depending on parental arrival and the length of camp participant's explanations of what they accomplished today. Students and parents can see the pendant designs begin to be 3D printed as they leave.

Predict and Disassemble, Day 3

Wednesday

8:00

Again the first half hour is designed for a flexible arrival time to accommodate each participant's arrival time. Participants and parents that arrive closer to 8:00 can see the pendants that were printed overnight. Participants are welcome to make changes to any of their designs from the day before. Participants that arrive closer to 8:30 will simply join the scheduled starting activity at 8:30.

8:30

Time will once again be given to examine the 3D-printed pendants. Students will be encouraged to record observations between what they thought was going to be printed and what was actually printed.

8:40

Participants will discuss changes that could be made to the pendant designs based on the observations made at the start of the day. These design change possibilities will be recorded in the engineering notebooks for use in the next time period.

9:00

Participants will use their design change ideas to update their pendant designs. The classroom assistants and instructor will once again provide "just in time" help with the 3D software. Design change times will vary based on each participant's chosen change or changes to make.

9:30

Because finish times will vary among participants, those that are satisfied with their pendant design changes will be able to make any changes they see fit to their project from day one, the bead design. Some may want to change their bead design to match their pendant design.

10:00

A break will be given with the opportunity to use restrooms, drinking fountains, or just simply get up from the computer and stretch.

10:15

Participants will each be given a mechanical object that hides the inner workings of its functions. The first object, shown in figure 6, will be a solar-powered doll that moves its arms and head like a bobblehead doll, but no human input is needed to begin the process. These particular dolls were purchased at a local Ace Hardware store with a 1-4 dollar price range. They are also available on Amazon and EBay under search a heading such as "Sunny Jigglers Animal". Participants will draw a sketch of the doll to the best of their abilities while being encouraged that, if they don't feel content with their drawing, they are welcome to add words to describe details that they may or may not be able to draw. The participants will then observe if the doll works with different light sources. For example, they can place the doll in the window or under different lights to see if there is any difference in operation. Different light sources will provide an opportunity for the inclusion of a STEM connection with the science of light. Participants will draw and record observations in their engineering notebooks. Participants will then draw and explain in their notebooks how they believe the doll works on the inside. They will be encouraged to include as much information as they can. They will furthermore be encouraged that they are to draw how they think it works while being reminded that it is okay if reality is different than their prediction. They will be encouraged to understand that their logical explanation to the workings is very valuable, even if it is different than the doll's design; they might come up with a new way to make the doll simply by stating how they *think* it works. The group members will share their predictions with the class, and the instructor will help the participants with the correct terminology as they describe how they think their dolls work. For example, if a student uses words like "see saw" to describe how parts move internally, the instructor will explain to the class that a STEM person would use the word "lever". Once everyone has had an opportunity to share and make changes to their predicted design, as they see fit, each person will take her doll apart. Special attention will be placed on safety, making sure that all participants wear safety glasses and are assisted with the disassembly as needed. Tools such as screw drivers and pliers will be explained and provided to the group. As the dissection takes place, the participants will record their observations in their notebooks. Cameras will be available, and those with cell phones will be encouraged to take pictures as they dissemble the doll. Tape and envelopes will be provided to keep track of all the pieces. Once the dissection has been completed, the participants will take a final picture or create a sketch of all the pieces taken apart in an exploded-view manner. Finally, participants will record their new-found explanation of how the object works in their notebooks. The assistants and instructor will continue to circulate among the group providing assistance and encouragement as needed. Lastly, the group members will discuss together how they think the object works, and the instructor will continue to subtly provide new science and engineering vocabulary to the students as they create consensus on the operation of the objects' workings and record observations in the engineering notebooks.

FIGURE 6 SOLAR POWERED TOY

12:00

Another lunch with a STEM professional will take place. This time the professional will be asked to come and speak to the participants directly. Participants will again be encouraged to ask questions. The intent was that the first lunch time speaker could be seen at her place of employment while the second lunch speaker would be present at the school. The second lunch speaker, being there in person, will be able to make a personal face connection to STEM. Having the speakers back-to-back each day may also give the participants the opportunity to ask a question that they thought they should have asked yesterday but were too nervous to ask or simply just thought of a question to ask later on the previous day.

12:30

The afternoon activity will include multiple objects for the participants to predict, document, disassemble, revise, and explain how the object works. Participants can choose from everyday items such as a hair dryer, curling iron, hand-crank flashlight, blender, drill, or various toys. Once again, this concept was modeled by Dr. Allen and Dr. Crawford in the UT classes “Design of Machine Systems” and “Engineering Design Methods”.

1:30

Before leaving, the participants will explain the workings of one object to the parents by means of their engineering notebooks. Participants can also show their revised pendants and beads to their family members.

G and M Codes to Program a CNC Machine, Day 4

Thursday

8:00

The arrival time begins at 8:00, but the official start to camp won't be until 8:30. However, now that the students have new STEM skills, they may find this time useful for disassembling another object or creating new 3D models for printing.

8:30

Similar in function to the 3D printers, the CNC machines take mathematical directions from a computer program and put them into action through the use of motors and sensors. Participants will learn how these CNC machines *remove* material, in contrast to the 3D printers which *add* material to produce a prototype.

8:40

The participants will embark on a tour of the six CNC machines throughout the building. Five of the six machines are different, with two machines as duplicates. The participants will be using the newest of the machines called a 2Op, made by Southwestern Industries. At the five different machines, participants will have the opportunity to drive the machines in their three principle axes, x, y, and z. Emphasis will be given to the mathematical axes so that the students will be able to draw on their previous mathematical knowledge from the academic school year.

9:00

The instructor will explain that the goal today is to create a leaf or flower press using STEM technology. The STEM technology being featured today is a CNC machine that runs off codes called G and M codes. This type of programming is very similar to playing the game "Battleship" or graphing points in a middle school pre-algebra or algebra class on a Cartesian coordinate system. Participants will begin by researching leaf and flower press images from the internet. This will give participants an opportunity to use one of the engineering design skills learned earlier in the week. They will be shown how to copy and paste images from the internet to a word processing document. Both images and web addresses will be documented in the word processing document and then printed to be glued into the engineering notebooks.

9:30

As the research of the leaf press images wraps up, participants will be shown some existing leaf presses that were made with flaws for the participants to avoid. Two main flaws that will be shown will include a press that has the bolt holes too close to the edges and a press that has the holes too far toward the center of the press. Group discussion will give an acceptable range for the holes to be located, allowing the participants to choose an exact number that they feel will produce the best working leaf or flower press. This will give everyone an opportunity to add their own design ideas to the leaf press.

10:00

A break will include a walk outside to look for a source of unique leaves or flowers to be used once the press is finished.

10:15

The leaf and flower press will have a completed size of four inches by four inches. Participants will draw a scale model of one level of the leaf press, including locating the ¼ inch holes to be made for the press bolts.

10:30

Through group instruction from the instructor and help from the assistants, participants will begin the programming process by locating the bottom left corner of their four inch square as their part origin, where x equals zero and y equals zero. They will then locate the four holes from the origin by using x and y coordinates. The z coordinates that do the actual drilling into the parts will be listed in series of steps; first the z height should be 1 inch, then the drill depth of -0.85 inches, and finally the drill height should return to 1 inch. Participants will be reminded from the earlier school tour that the z axis is used for the drilling direction on a CNC machine. To start the program, students will locate the hole locations from the origin with the x and y axis. The z axis will then be used for drilling and for moving the tool above the press when moving from one hole to the other and for drilling the depth of the bolt holes . Participants will be instructed that the material thickness for the press will be ¾ of an inch thick. On the scale model drawing, participants will locate when the height of the cutting tool should be above the part by coloring those locations yellow; this includes when the tool is moving from one hole to another. Figure 7 provides an example of how participants will use red ink to indicate when the tool height is below the part; for instance when the holes are drilled to make the press bolt holes. A list of G codes will be given to the students that are used to move the CNC machine at a safe speed. Each student's program will be similar in that they should all move from one hole to another ¼ of an inch above the press surface. Each student's program should be the same in that they all drill to a depth of -0.85 inches, to make a through hole. However, each student's program will vary based on what x and y hole locations they chose based on the range of hole locations decided in class. Programs will be reviewed by the assistants or instructor; figure 8 gives an example of a possible CNC program.

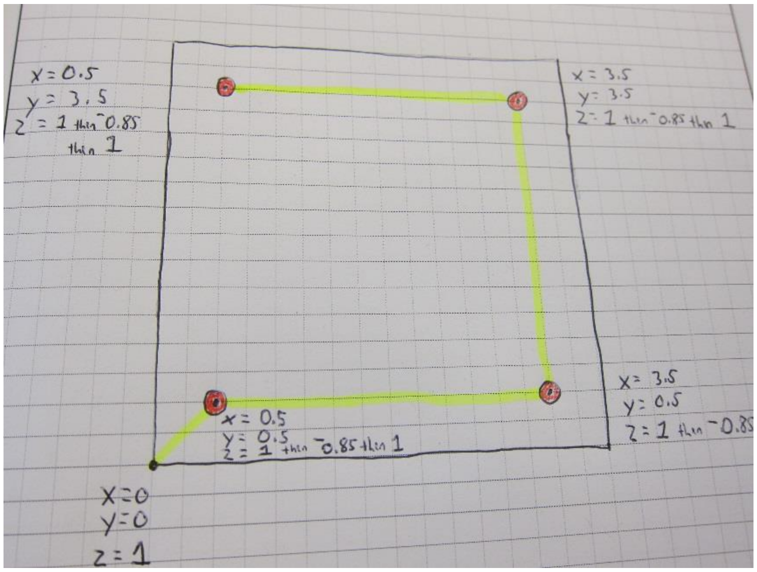

FIGURE 7 NOTEBOOK SKETCH

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N100 G00G90
N110 T1S3000
N120 G00X0Y0Z1
N130 G01X.5Y.5Z1
N140 G01X.5Y.5Z-.085F2
N150 G01X.5Y.5Z1
N160 G01X3.5Y.5Z1F5
N170 G01X3.5Y.5Z-.085F2
N180 G01X3.5Y.5Z1
N190 G01X3.5Y3.5Z1F5
N200 G01X3.5Y3.5Z-.085F2
N210 G01X3.5Y3.5Z1
N220 G01X.5Y3.5Z1F5
N230 G01X.5Y3.5Z-.085F2
N240 G01X.5Y3.5Z1
N250 G01Z10
```

FIGURE 8 CNC CODE EXAMPLE

12:00

Lunch, weather permitting, will be held outside in the outdoor classroom as a picnic, so that campers can continue to observe flowers and leaves that they may like to place in their presses.

12:30

Participants will then load their programs and parts into the CNC machine. Each participant will locate the origin of the part by moving the machine to the origin, the bottom left corner of the part. The offset numbers will be cleared and the programs will be run. Each set-up time and program should take about 5 minutes to run. Once about 1/3 of the programs are run, participants will be given sand paper to sand any rough or sharp edges that they feel. Final assembly will take place once the sanding is completed. Participants that are finished first will be called upon to help the assistants and instructor assist those who need to finish running their CNC programs. Again, it is important that the participants see the assistants being active users of the technology and then seeing themselves as active users of the technology. Though the material could be wood, acrylic, or metal, a plastic leaf press is shown as an example in figure 9. Spacers can be added to press more flowers or leaves at one time.

FIGURE 9 ACRYLIC LEAF PRESS

1:30

Once again the last half hour of time will be dedicated to allowing the participants to show their parents or guardians what they have created today. Participants will be encouraged to demonstrate their scale drawing and program along with operating the CNC machine and explaining how it is similar to the 3D printer, but instead removes material rather than places material. Campers will be encouraged to decorate their leaf or flower press that evening with materials that they have at home and to bring them back the next day to show to their fellow campers. This is not a mandatory activity, but rather an opportunity for campers to make use of another set of skills that they may have not been able to use yet this week. Stickers, markers, paint, wrapping paper, etc. could be used. A few supplies will be on hand for those who may not have any at home.

Electricity, Crafting With Hot Glue and Welding, Day 5

Friday

8:00

The staggered start to the last day will be an opportunity for campers to show their press decorations. By this time in the camp, the campers will be familiar with each other and may enjoy just making memories through conversation. Likewise, a few parents may have begun to make connections with other parents and may converse with one another before they leave for the day.

8:30

A brief overview of welding will be given by the instructor. Using ice cubes, each participant can experience welding. The participants will place an ice cube in each hand for a few seconds to begin to melt it. When they remove the heat of their hands and place the ice cubes next to each other on a desk, the ice cubes will freeze back together. A simplified explanation of welding is the same concept. Two objects are heated to a liquid state, the heat source is removed, the objects are placed next to each other, and the objects freeze back together.

8:40

A tour of the welding machines and welds found in the school will take place. In the manufacturing facilities of the school, there are currently six welders that represent five different methods of welding. A brief explanation will be given of each type of welding emphasizing the source of the "melting", or welding, to build on the earlier ice cube activity. The participants will weld using a gas metal arc welding (GMAW) process machine made by Miller, millerwelds.com. Technically the participants will be using a gas metal arc welding (GMAW) process. A tour of visible welds throughout the building will also be given. This will give participants the opportunity to see what a finished product can look like before they attempt their first weld.

9:00

In order to weld safely, a number of items need to be worn by the person welding. To simplify the process, each student will use a hot glue gun to practice making a weld bead on paper. A weld bead is simply a line of material that forms a weld. The hot glue gun will allow the participant to practice the mechanics of welding without the frustrations that come with wearing safety equipment. Though a half hour is probably not long enough to establish long-term muscle memory, it will lay the groundwork for a successful afternoon activity when participants have to wear all the protective welding gear and weld for real.

9:30

The project will be to create an object of the student's choice out of metals strips that are 0.75 of an inch wide and 0.125 of an inch thick. These material strips will allow the student to make alphabetical letters, symbols, or even small silhouette dioramas. Students will begin to research objects similar to yesterday's research by using the internet as a source of pictures. Once again reference to an engineering design process will be made.

10:00

A stretch, water, and bathroom break will be given. Students with remaining time will be given opportunities to search the school for more examples of welding.

10:15

An introduction to two types of electrical circuits, parallel and series, will be given. Participants will be shown examples in their everyday lives of each type of circuit. A simplified welding circuit will be demonstrated.

10:30

Participants will be able to create prototypes with strips of paper, scissors, tape, and their engineering notebooks. Participants will be reminded that the final material they are going to use is steel. Though paper makes a good prototype material, steel is much more difficult to fold and bend in the limited time given for this activity.

11:15

Safe welding habits will be explained to the participants. Safety glasses must be worn at all times in the manufacturing facilities. When welding, no skin can be exposed to the arc. Ventilation must be turned on. Never look at the welding process without the proper shielding mask. Only weld under the supervision of your instructor.

11:30

Participants will cut out and glue actual-sized paper strips together with a hot glue gun in the same manner as a welder, not as a person building crafts. That is, the glue bead will span the joint of the paper prototypes, not to be placed between the faces of the paper pieces. Figure 10 shows an example of this technique along with the welded final project. The assistants and instructor will circulate throughout the room to provide assistance and feedback as to proper holding of the glue guns to simulate the welding process accurately. Participants are allowed to make design changes to their design based on their design's observed weld ability from the hot glue gun simulation.

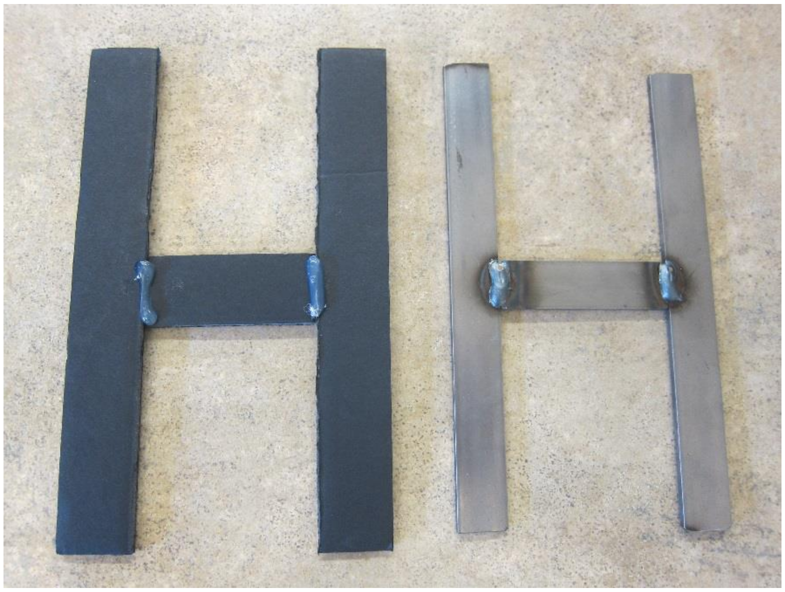

FIGURE 10 PROTOTYPE AND WELD EXAMPLE

12:00

Participants will eat lunch as a group to relive memories from the week-long camp. Camp shirts will be passed out at this time, and each participant will be given opportunities to sign each other's shirt with permanent marker.

12:30

During this time period everyone will be in the manufacturing facility accomplishing two main goals: some participants will be cutting the metal they require for their project, while other members will be practicing welding. The project metal can be found locally at speedymetals.com. Camp assistants will help students with the cutting process of their metal pieces while the camp instructor will help with the welding practice. The camp instructor will also oversee all safety in the manufacturing facility. About halfway through this time block those practicing welding will switch to cutting their metal supplies, while those that started cutting their metal supplies first will switch to practicing welding.

1:00

Participants will use clamps and locking pliers to hold their designs in place before the welding process begins. When the projects are clamped, the participants will enter the welding booths to weld their designs in place. Once the welding is done, participants will cool their designs by quenching them in a water table. (Figure Z)

1:30

Participants and parents/guardians will be thanked verbally for their participation. Participants will once more show their parents/guardians what they learned that day in camp. A final group photo will be taken of everyone to display and document the camp.

References

Aschbacher Pamila, Gilmartin Shannon K., Li Erika (2006). The Relationship Between Interest in Physical Science/Engineering, Science Class Experiences, and Family Contexts: Variations by Gender and Race/Ethnicity Among Secondary Students. *Journal of Women and Minorities in Science and Engineering*, *12*, 179-207.

Boaler J. (2002). Paying the Price for "Sugar and Spice": Shifting the Analytical Lens in Equity Research. *Mathematical Thinking and Learning, 4(2&3),* 127-144.

The U.S. Bureau of Labor and Statistics. (2014) Household Data Annual Averages, Employed Persons by Detailed Occupation, Sex, Race, and Hispanic or Latino ethnicity. Retrieved July 21, 2015 from http://www.bls.gov/cps/cpsaat11.pdf .

Correll, S. (2001). Gender and the Career Choice Process: The Role of Biased Self-Assessments. *American Journal of Sociology, 106(6),* 1691-1730.

Dinella L., Fulcher M., Weisgram, E. (2014) Sex-Typed Personality Traits and Gender Identity as Predictors of Young Adults' Career Interests. *Archives of Sexual Behavior, 43(3),* 493-504.

Heilbronner, N. (2013). The STEM Pathway for Women: What Has Changed? *Gifted Child Quarterly, 57*, 39-55.

Kekelis, L. S., Wepsic, A.R., and Heber, E. (2005). Hurdles in the Pipeline: Girls and Technology Careers Frontiers: A Journal of Women Studies*, Vol. 26(1*), 99-109.

Lee, K., Sriraman, B. (2012). Gifted Girls and Nonmathematical Aspirations: A Longitudinal Case Study of Two Gifted Korean Girls. *Gifted Child Quarterly, 56*, 3-14.

Lytle J., Baakken L., Romig C. (1997) Adolescent Female Identity Development Sex Roles, *37(3/4),* 175-185.

Scherrer, C. (2013). Outreach Emphasis on the Human Impact Potential of Engineering Improves Perceptions Of Underrepresented Groups. *Journal of Women and Minorities in Science and Engineering, 19*, 37-45.

Schwartz, S. (2005). A New Identity for Identity Research: Recommendations for Expanding and Refocusing the Identity Literature. *Journal of Adolescent Research, 20*(3), 293-308.

VITA

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