AN ABSTRACT OF THE THESIS OF

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A video exploration and analysis of under-representation.

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Toni Doolen

In a society where equality is sought as the norm, occupational gender representation is still skewed in some disciplines. One field where gender equality in representation has not yet been achieved is engineering, whether in college or at the professional level. This imbalance is not only a potentially vicious cycle but also has numerous negative implications. Engineering is a discipline that benefits from and requires diversity in background, experience, thought processes, and other traits that both men and women bring. This project sought to gain a deeper understanding of the issues of female under-representation in engineering programs at the college level, and the resulting under-representation of women awarded undergraduate engineering degrees and the subsequent under-representation in the workforce. Analysis of recruitment processes and interviews with current engineering students were used to study this topic and provide a basis for the creation of a recruitment video.

Key Words: Engineering, Women, Recruitment, Video

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Women in engineering:

A video exploration and analysis of under-representation

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

Justin Chi, Author

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Personal Statement

My involvement with the College of Engineering's Ambassador Program began through photographing a summer program in 2011. The summer program is run through the Office of Women and Minorities in Engineering and seeks to enthusiastically engage potential students, specifically women and minorities, in the field of engineering, and help them throughout their college experience. Since then, I have been involved mostly through media, photographing events and making videos with other ambassadors. A video I made with fellow ambassador Cassandra Loren, titled "So tell me, why you want to be an engineer?" won the Bechtel Engineering Student Video Contest in 2012. A fellow engineering and University Honors College colleague, Kristina Schmunk, wrote her thesis on "Framing Engineering for Women in Undergraduate Recruitment" and our video was analyzed in her study. Her exploration of how to better recruit women for undergraduate engineering programs is the starting point for my study, and through her findings and my research and interviews, I hope to make an effective, high-quality, and fun video to excite potential students about engineering.

1 Introduction

In a society where equality is sought as the norm, occupational gender representation is still skewed in some disciplines. Fields where gender equality in representation has not yet been achieved are the STEM (science, technology, engineering, and mathematics) fields. The under-representation of women in engineering is apparent both in college and at the professional level. At the undergraduate level, the percentage of women engineers receiving engineering bachelor degrees has increased, but only by 0.3% to a 2011 nationwide value of 18.4% (Yoder, 2011). The gender gap is variable within different engineering disciplines. For example, 44% of environmental engineering degrees are awarded to women (Yoder, 2011). The lowest percentage of degrees awarded is in computer engineering, with only 9.4% of engineering degrees being awarded to women, as shown in Figure 1 (Yoder, 2011).

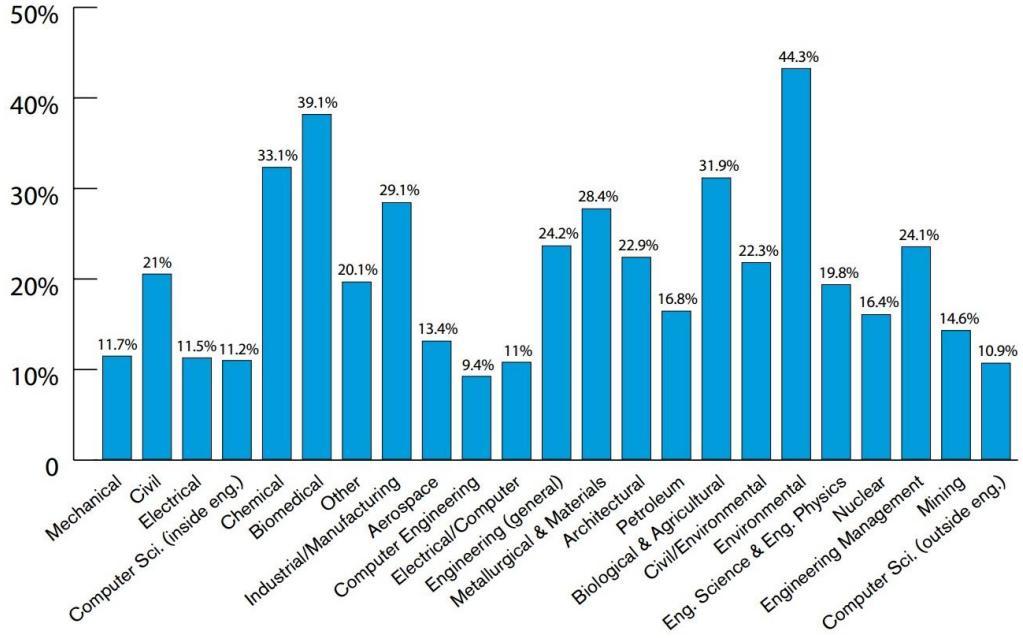

Figure 1: Engineering bachelor degrees awarded to women, by discipline, in 2011. Women were awarded 18.4% of all engineering bachelor degrees.

At Oregon State University (OSU), trends are similar in that the engineering programs with the highest percentage of female are the science-based departments. In the fall term of 2012 at OSU, the three programs with the highest percentage of women enrolled in engineering were Ecological Engineering with 45.2%, Environmental Engineering with 41.9%, and Bioengineering with 41.7% (Oregon, 2012). These three programs are some of the smaller programs in the OSU College of Engineering (CoE), only representing just over 8% of the enrolled engineering student population (Oregon, 2012). It is interesting to note that the fourth highest percentage is 18% lower, with 23.7% of students in Industrial Engineering being female (Oregon, 2012). These percentages are a reflection of national trends and consistent with the national tendency of women in engineering to gravitate towards science-based engineering programs.

In terms of the number of female students, the largest number of women are enrolled in the Chemical Engineering program with 106 (21.9%) and Civil Engineering program with 101 (21.8%) These two program enrollments are the sixth and seventh highest female percentages in the college (Oregon, 2012). Comparing Schools within OSU CoE, Chemical, Biological, and Environmental Engineering (CBEE) has the most women in total with 235 female students, followed by Electrical Engineering and Computer Science (EECS), Mechanical, Industrial, and Manufacturing Engineering (MIME), and Civil and Construction Engineering (CCE), with 126, 125, and 120 female students, respectively (Oregon, 2012). See Figure 2.The two Schools with the fewest number of women are Biological and Ecological Engineering (BEE) with 33 female students, and Nuclear Engineering and Radiation Health Physics (NERHP), with 29 female students.

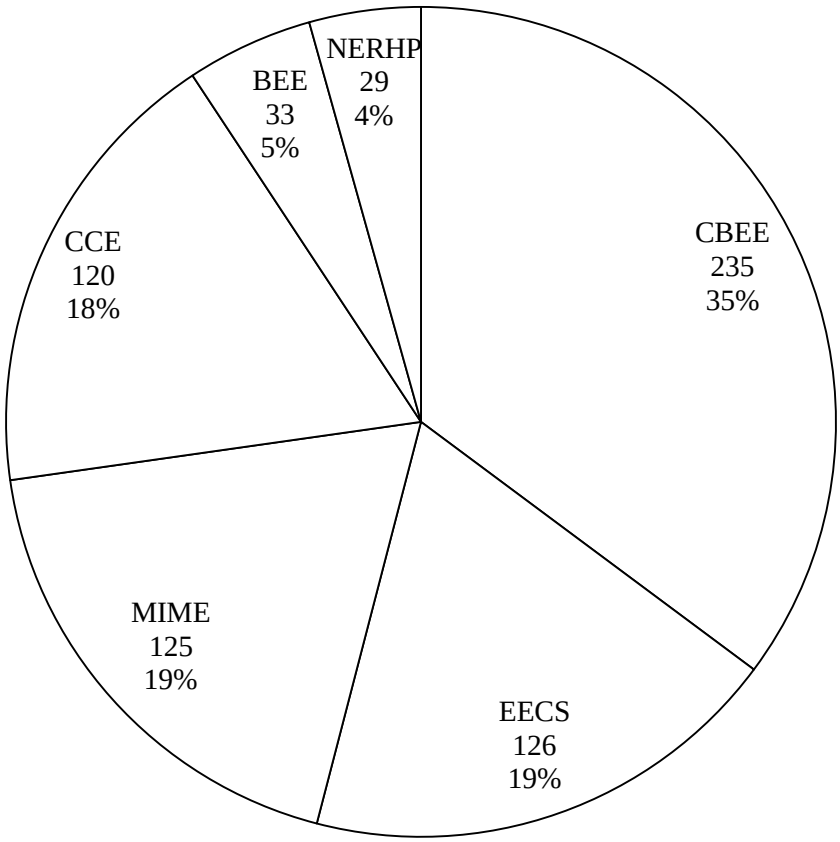

Figure 2: Total number and percentage of women enrolled in undergraduate engineering programs at Oregon State University by school in 2012.

The programs with the lowest percentages of female students Electrical and Computer Engineering with 8.7%, Mechanical Engineering with 7.8%, Construction Engineering Management with 7.1%, and Manufacturing Engineering with 6.3% (Oregon, 2012). These percentages mirror national data where electrical and mechanical engineering disciplines have the lowest number of women as percentage. While there are a significant number of females in Mechanical Engineering at OSU relative to other

programs, the large number of males in the Mechanical Engineering (nearly 1000) make the percentage of women very low overall.

The enrollment and graduation rates by gender for undergraduate engineering students at Oregon State University are also revealing. During the fall term of 2011, women accounted for 14.9% (646 of 4,343) of enrolled undergraduate engineering students, compared to a campus-wide enrollment of women 47.1% (Enrollment, 2011). In stark contrast, the College of Public Health and Human Sciences was 76.9% female, with a total enrollment of 3,359 students (Enrollment, 2011).

Graduation data show that 14.8% of undergraduate engineering students graduating in 2012 were female out of 893 total students (Graduation, 2012). Review of data from previous years indicates that the percentage of women graduating with engineering degrees was increasing up to 2011 (18.1%) (Graduation, 2011). However, the percentage of women graduates dropped in 2012. Enrollment data from 2007, four years before the graduating class of 2012, show that only 13.1% of engineering students were female (Enrollment, 2007). This percentage did not change significantly in the next four year period (Enrollment, 2007). These data show an overall increase in the percentage for women in undergraduate engineering, with the exception of 2012, and a high percentage of female graduates who complete, relative to the overall undergraduate female representation. While women may be under-represented upon entering higher education, retention and completion rates at Oregon State University are higher than the retention of male students.

This imbalance in female representation is not only a potentially vicious cycle but also has numerous negative implications. The vicious cycle is the harmful cause and

effect progression of having under-representation of women in engineering. Current under-representation continues to fuel negative misconceptions, supporting continued under-representation, through misinformed and under-educated students on the full spectrum of what it means to be an engineer (Hill, 2010). The presence of strong role models also has been identified as an important recruitment and retention tool. The deficit of women in engineering also impacts the chances young women will have a chance to interact with a professional and successful female engineer (Hill, 2010).

Engineering is a discipline that benefits from and requires diversity in background, experience, thought process, and other traits that the presence of both males and females bring. An example of this need, highlighted in OSU Engineering's recruitment presentations is how a group of engineers designed and constructed a platform stage. During the show, a woman's high heels punctured the stage because the engineering and design team, mostly male, did not account for the amount of concentrated pressure that could occur at the heel point of some shoes. Understanding and bridging the under-representation gap has the potential to improve engineering practice.

The gender gap in engineering is difficult to correct. Many high school students do not consider engineering as a potential field of study because they assume they would not enjoy the field or would not be successful in the courses required to become engineer (Hill, 2010). These barriers are due, in part, to stereotypes developed from visual media, experiences, and through a perceived understanding of social norms associated with the engineering discipline.

This thesis analyzes recruitment techniques and identifies positive and effective efforts, while simultaneously noting and attempting to counter negative recruitment techniques. A literature review was conducted to investigate past studies and findings regarding the under-representation of women in engineering. Important topics as identified from the literature review along with general engineering topics were used to form a set of interview questions. These questions were used to understand current engineering students' viewpoints of recruitment processes.

Interviews were scheduled with student volunteers and recorded. Interview responses were analyzed and specific topics appearing across multiple interviews were tabulated and tracked. Understandings gained from the review of the literature and the interviews provided the foundation for the production of an engineering recruitment video. The engineering recruitment video attempted to deviate from traditional engineering videos through video style and presentation of engineering. This thesis concludes with a discussion of the best use for the developed video.

2 Literature Review

The under-representation of women in engineering is widespread and well documented. There are a myriad of discussions, studies, and proposed strategies for correcting the under-representation. The literature on the under-representation can be broken down into three broad topics: the perception of engineering during childhood, the presence of science, technology, engineering, and mathematics (STEM) during middle and high school, and the recruitment and retention of students in undergraduate programs.

2.1 Engineering Preconceptions

Students in elementary school are not often familiarized with the field of engineering. A 2006 study conducted in Organisation for Economic Co-operation and Development (OECD) countries showed that in 15-year olds, only 5% of girls expect a career in engineering and computing while 18% of boys expected a career in engineering and computing (What, 2012). Specifically for the United States, only 3% of girls and 16% of boys expected to work in engineering and computing (What, 2012). These results suggest that upon entering high school, when students start to figure out what direction they want to take in life, few girls are considering the field of engineering. Among the high-achieving students in the study, there was little difference in the ratio of girls that were planning to pursue engineering - these girls tended to direct their ambitions towards science, health, and medicine (What, 2012).

Stereotypes may be part of the reason that girls do not consider engineering careers. Some stereotypes related to engineering support negative preconceptions of women in engineering fields. Traditionally, more men have pursued engineering than

women. As a result, the tendency is to picture engineers as men with hardhats or working on a computer. Rarely are engineers thought as women. This bias is similar to the association between women and teachers and women and nursing health professionals. Not only can these stereotypes and preconceptions about engineering impact a girl's thoughts and decisions related to engineering as a career, but such stereotypes can also threaten a woman's performance in engineering.

Stereotype threat is defined as a concern or anxiety that one's performance or actions can be seen through the lens of a negative stereotype, a concern that disrupts and undermines performance in negatively stereotyped domains (Shapiro, 2011). This undermining can occur from different sources and can be self-implicating or come from others. Self-implication stereotype threats are dangerous because they can seemingly confirm an untrue stereotype as a result of an action or inaction, even if the untrue stereotype is just a fleeting thought (Shapiro, 2011).

Stereotype threats from others include fears that others (both known and unknown) would judge not only the person, but also the attributing group, against the stereotype (Shapiro, 2011). These stereotypes threats from others can come from any source, friendly or not, and can turn into self-implicating stereotype threats (Shapiro, 2011). While the person must have thoughts of the stereotype for self-implicating stereotypes, the person must believe that others endorse the stereotype for stereotype threats from others to have an impact (Shapiro, 2011). Engineering stereotypes typically have a negative impact on the decision making process with females in engineering, and the presence of stereotype threats furthers the potential harm of stereotypes that may have been already in the minds of very young women from a very young age.

Virginia Tech and the University of Waterloo collaborated on a study titled "The Effect of Stereotype Threat on Women's Performance on the Fundamentals of Engineering Exam." This project analyzed the differences in test scores between men and women taking the same easy or hard engineering test with the presence of stereotype threats (Bell, 2002). Results from the study revealed the women and men performed equally well on the easier test, but women had a significantly lower average score than men on the harder test (Bell, 2002). This difference can be attributed to both self-implicating stereotype threats and stereotype threats from others. The women may experience self-pressure to perform equally if not outperform the males, who are stereotypically more keen to engineering topics. External stereotypical threats could be present from their fear that if they underperform, others will view them, and potentially all women, as less adequate for the field of engineering (Bell, 2002).

The potential harm caused by stereotypes and stereotype threats can severely limit the appeal of engineering to women. Because these threats can come from nearly any source, and can start influencing females at a young age, such stereotypes must not only be countered, but must also be reversed (Hill, 2010).

With a lack of women in engineering comes not only the reaffirmation of stereotypes but also a lack of role models. The program IGNITE, Inspiring Girls Now In Technology Evolution, has taken steps in high schools to combat the lack of professional women in girls' lives (Platz, 2012).

2.2 Middle and High School Impact on Mindset

IGNITE was created by Cathi Rodgveller when she saw that most of the female engineering figures in children's lives often came from television shows or movies (Platz, 2012). The IGNITE program started in Seattle where professional women and occasionally men, donate time to visit classrooms to talk to the girls about professions. Following the visit, these professionals maintain close contact with the schools and help organize workshops, field trips, and most importantly, continue the mentorship (Platz, 2012). The difference with IGNITE is that the girls in the schools receive personal connections with a real role model, and the role model stays connected to them throughout the school year (Platz, 2012).

Personal connections with successful adults can go a long way in helping shift and change girls' perspectives on engineering (Platz, 2012). The program has been so successful that it has spread internationally, and past IGNITE students that have pursued engineering careers have returned to help the program (Platz, 2012).Utilizing past IGNITE students is great for the program. Similarly, OSU Engineering ambassadors, who were recruited into engineering after talking to an ambassador in high school, are great examples of the successes of recruitment programs and are also passionate about recruiting. IGNITE is now looking to continue their success by involving girls earlier in middle school and also by continuing support and mentorship into undergraduate studies (Platz, 2012).

In addition to providing role models, there must be other strategies to help increase interest and overcome obstacles in garnering interest by females in engineering. The University of Hartford recognized that the low percentage of time that middle and

high school students were exposed to STEM topics needed to be increased and initiated an immersion program to find results (Ilumoka, 2012).

With the average female teenager being exposed to less than three hours a week of STEM material, the University of Hartford and the National Science Foundation started after school hands-on workshops, summer camps, mentor programs, and parent/guardian workshops to create a well-rounded, STEM immersion atmosphere for students (Ilumoka, 2012). A key part of their decision-making for programs was in analyzing the differences between how boys and girls experience STEM activities, including prior knowledge, attitude, interest, competence, and reasoning (Ilumoka, 2012).

Out of the many approaches taken by the program, the inclusion of art and physical activity was one approach to incorporate as many nontraditional fields as possible. One summer camp activity involved writing lyrics to a hip hop song and then dancing to it with the help of a professional dance instructor, which students performed at the conclusion of the summer program (Ilumoka, 2012). One of the summer programs focused on mixing and modifying music while another focused on artificial limbs and biomedical topics, both areas that girls were more attracted to in the broad spectrum of engineering (Ilumoka, 2012). Giving students hands-on time with STEM, especially in topics of more interest or less known connection to engineering, can greatly improve the interest and confidence in girls and boys alike (Ilumoka, 2012).

Generating interest and reducing the negative impact of preconceptions may seem within reach, however there are other difficulties in recruiting women into engineering. Once in engineering, students often struggle to stay in programs for varying reasons, not excluding previously mentioned stereotype threats.

2.3 Recruitment and Retention

The recruitment of women in engineering is a topic with numerous difficult issues. Everything from the portrayal of engineering or framing of engineering to what images and words are used all have some role in the effectiveness of a recruitment tool (Hill, 2010). The College of Engineering at Colorado State University started a recruitment program in 2006 that included surveying, website revamping, a new communications plan, and a student ambassador program. These efforts have increased freshman enrollment of women engineers by a factor of 2.04 (Woods, 2012).

In a survey of engineering students, 94.4% of females responded that helping others was essential or very important to them when selecting engineering as a major, while 63.5% indicated the importance of environmental conservation and clean-up (Woods, 2012). Another result showed that only 40.1% of females said they chose engineering to design, build, or deconstruct materials, while this was the top response (68.8%) for selecting engineering for males (Woods, 2012). These results indicate that helping others and the environment are important selection criteria for women when selecting a career, while aspects associated with engineering such as building and problem solving are not as important to many females.

The portrayal of the engineering field during recruitment processes, which highlights different aspects of engineering, could help increase interest among females. Results from a study on framing engineering for the recruitment of women in engineering recommended avoiding stereotypes and the less interesting aspects of engineering, as well as de-emphasizing the importance of math and science (Schmunk, 2012). Instead, it

is recommended that communication skills, flexibility, societal benefits, and social engagements be the primary emphasis (Schmunk, 2012).

Upon successful recruitment of women into engineering, there are still problems retaining women through undergraduate programs until graduation. A retention analysis conducted at Georgia Institute of Technology looked to analyze why it took an average of five years to complete an engineering bachelor's degree instead of the curriculum based four year graduation track (Blasick, 2012). In universities around the nation, students are forced to, or elect to take the extra year for many reasons including work experience, studying abroad, or the difficulty of the program. This retention study was designed to clarify if the majority of students were taking an extra year for positive reasons or negative reasons.

Results of the study showed that while the majority of students experienced both positive and negative graduation timeline setbacks, the largest group of women (27.8%) graduated in continuous enrolled terms adding up to four years by taking summer classes and entering college with credit (Blasick, 2012). The women who drop out of engineering typically switched to another career due to interest or difficulty (Hill, 2010).

This research combines the finding from this review of the literature with interview responses from engineering students to develop better engineering recruitment materials. There are many more factors that affect women and their decisions with engineering; however, this study focused on the three broad areas of preconceptions, early involvement, and recruitment and retention in higher education. The details of the methodology used to collect interview data and to develop recruitment materials are described next.

3 Methodology

Prior to the start of the data collection, the research methodology were reviewed by OSU's Institutional Review Board (IRB) to ensure that the recruitment and interview processes would not result in harm to any research participants. The protocol submitted to the OSU IRB is included in Appendix A. The exemption approval form is included in Appendix B.

3.1 Interview Process

Interviews with current women engineering students provided insight on first-hand experiences with recruitment and retention of women in engineering. These interviewees were recruited via e-mail through connections formed through engineering organizations, the OSU Engineering Ambassador Program, or from personal connections. The recruitment e-mail used to inform potential participants about the research is included in Appendix C.

Interested volunteers replied to the e-mail, and interview sessions were scheduled at the convenience of the volunteering participant. Interviews were held on campus unless otherwise requested by the participant. Participants who agreed to participate signed a consent form, included in Appendix D. The consent form included general information about the study and participant rights. An option was included to allow the participant to release limited personal information to be used in the recruitment video. All interview sessions were video recorded. This also allowed for use of audio clips and video footage in the recruitment video created as part of the study.

Participants were asked questions as specified in the interview protocol. The questions are included in Appendix E. Some follow-up questions were asked to gain more insight, to clarify understanding of responses, or to obtain more details. Interviews typically took 15 minutes to 30 minutes. Notes were taken during the interview to flag statements or insights that seemed particularly relevant. These notes were then used when reviewing the recorded transcripts to identify excerpts from the full pool of responses that would be most appropriate for categorization and analysis in this study.

Flagged interview responses were sorted into groups of categories related to some of the themes found in the review of the literature on the under-representation of women in engineering: negative/positive preconceptions, early involvement influencing mindsets and confidence, recruitment flaws/strengths, as well as other aspects related to the under-representation of women in engineering.

Interview quotes were then analyzed, taking into account the background of the interviewee. Relevant background information included the interviewee's current occupational status, educational history, and experiences in engineering. Responses to interview questions were also compared to published findings, surveys, and other data taken from the literature review.

3.2 Video Process

Video development incorporated content from two sources: interview responses and the literature review. In addition cinematic considerations were taken into account in developing the video. Important cinematic considerations included the topic, tone, location, personnel, script, music, and filler sequences. Engineering student volunteers

were recruited to create footage that would enable the video to maintain gender and ethnic diversity. This additional video footage was and recorded on campus at the convenience of volunteers.

A Sony Alpha SLT-A55, with varying lenses, was used to record interviews and recruitment video footage. The recruitment video was edited and published using Adobe Premiere Elements 11 and uploaded through YouTube for public viewing and dissemination.

4 Discussion

4.1 Interview Results

Interviews were conducted with ten engineering students who represented different engineering disciplines and various class standings. The general topics as stated in the methodology of negative/positive preconceptions, early involvement influencing mindsets and confidence, recruitment flaws/strengths, appeared in various situations throughout all interviews. Specific interview questions corresponded to these general topics, as shown in Table 1.

Table 1: Literature review themes and corresponding interview questions regarding the recruitment of women in engineering.

Literature Review Theme	Interview Question
Preconceptions	1. Why are you considering or why did you consider studying engineering? 4. What do you think are the least and most attractive aspects of engineering to a high school or college student, more specifically for a woman? 8. What stereotypes and thoughts come to mind when you hear the word engineer or engineering? More specifically, what people, qualities, skills, jobs, and conditions come to mind? 9. What stereotypes and thoughts do you think come to mind when girls in high school hear the word engineer or engineering? 10. Why do you think any previously mentioned stereotypes are or are not true?
Involvement and Mindset	7. If you were given one minute to convince a girl or young woman to study engineering, what would you say? 11. How have these stereotypes and thoughts affected your decisions with engineering? 12. How might difficulties have presented themselves because of these stereotypes?
Recruitment	5. How do you think women should be recruited into the engineering field? 6. What do you think is or isn't working with the recruitment of women in engineering? 13. What do you think can be done to reverse stereotypes or pre-conceptions related to the engineering field?

Responses to the first question of why the interviewees considered engineering all captured positive preconceptions related to the belief that careers in engineering would give the interviewee an opportunity or an ability to improve lives and to improve the world. This general theme was also present when interviewees were asked to identify the most attractive aspect of engineering. The other repeated positive preconception of engineering was job security and the potential for obtaining high paying jobs. Cassandra Loren, a senior bioengineering student said that she chose engineering because "it sounded like something I could make a difference with, that would give me good career security and stability and still be fun and interesting."

Negative preconceptions were noted by interviewees most often when prompted for the least attractive aspects of engineering from their own perspective as well as from the perspective of a high school girl. Negative preconception themes included engineering as a male-dominated field, requiring students to spend a lot of time at a computer, and engineering studies being difficult and arduous. A common expressed, negative stereotype was that engineers were nerdy, geeky, sat behind computers, and spent too much time engaged in playing video games. Sara Quitugua, a sophomore Civil Engineering student, said that in her experiences with talking to high school females, they think that engineers are all "just nerdy with glasses and just sit on their computers the entire time and are all guys." These themes were echoed in responses to many of the interview questions. Some interviewees felt that it was difficult to overcome these stereotypes when they were deciding whether or not to study engineering. Interviewees stated that they were afraid to become what they described and that they preferred to not end up working with those "types" of people.

A universal theme from the interviews was that girls need to understand that they can succeed and be competitive in the engineering field. Ann Swanson, a senior environmental engineering student, stated "It should be really well verbalized that you can do just as well as anybody in engineering." Some interviewees also mentioned being afraid or uncertain about whether or not they would fit in or do well in engineering because of a lack in prior experiences. These same interviewees also identified that gaining confidence and getting encouragement were crucial to the recruitment of females and ultimately to success in engineering. Swanson later said that while "women may know that themselves, it really helps to hear that (from others)." This response reinforces the importance of external support and the need for positive input for females in the recruitment process. Alexandria Moseley, a senior studying Industrial and Manufacturing Engineering stated, "in order to secure more women into our field (engineering), that affirming them that yes, you are capable, you have the skills…that affirmation I think is something we can do better." Recruitment processes incorporating affirmation would be more effective in both recruitment and retention.

The recruitment flaws and strengths identified by the interviewees were varied. Most of the interviewees continued to focus on the negative stereotypes and felt that combatting and reversing negative stereotypes would present the greatest benefit for recruitment efforts. The majority of interviewees mentioned that involving role models, whether current female engineering students or professional women engineers would be beneficial. Julie Rorrer, a junior studying Chemical Engineering stated that "having a good role model to look up to is an important thing." Also mentioned was the importance of emphasizing the non-technical aspects of engineering.

Katie Kline, a sophomore studying Civil Engineering, stressed the importance of having more engaging presentations, because bland PowerPoint presentations and other talks in her opinion were "usually stereotypical… when a lot of the time it is nothing like that." Recruitment flaws included incorporating or reinforcing negative stereotypes, even when unintentional, as well as presenting details that were intimidating. Additionally, technical talk and highlighting to rigor of engineering studies were felt to be flaws in recruitment efforts and messaging.

Some of additional responses provided by interviewees and relevant to this study were a desire to see positive results from engineering, the need to highlight the exciting engineering careers of women, and stressing the importance of including the female perspective in creating modern engineering.

4.2 Video Production

The video, titled "Engineer a Better Tomorrow," featured a variety of engineering students from Oregon State University, with both gender and ethnic diversity highlight in the visual and audio portions. The video was shot in a "quick-reel" style where each video sequence is a short 2-3 second shot quickly followed by another. This style of video was chosen to maintain audience interest by quickly changing scenes. Engineering recruitment videos do not often employ this form of video style. The YouTube thumbnail link and stills from the video are shown in Figure 3.

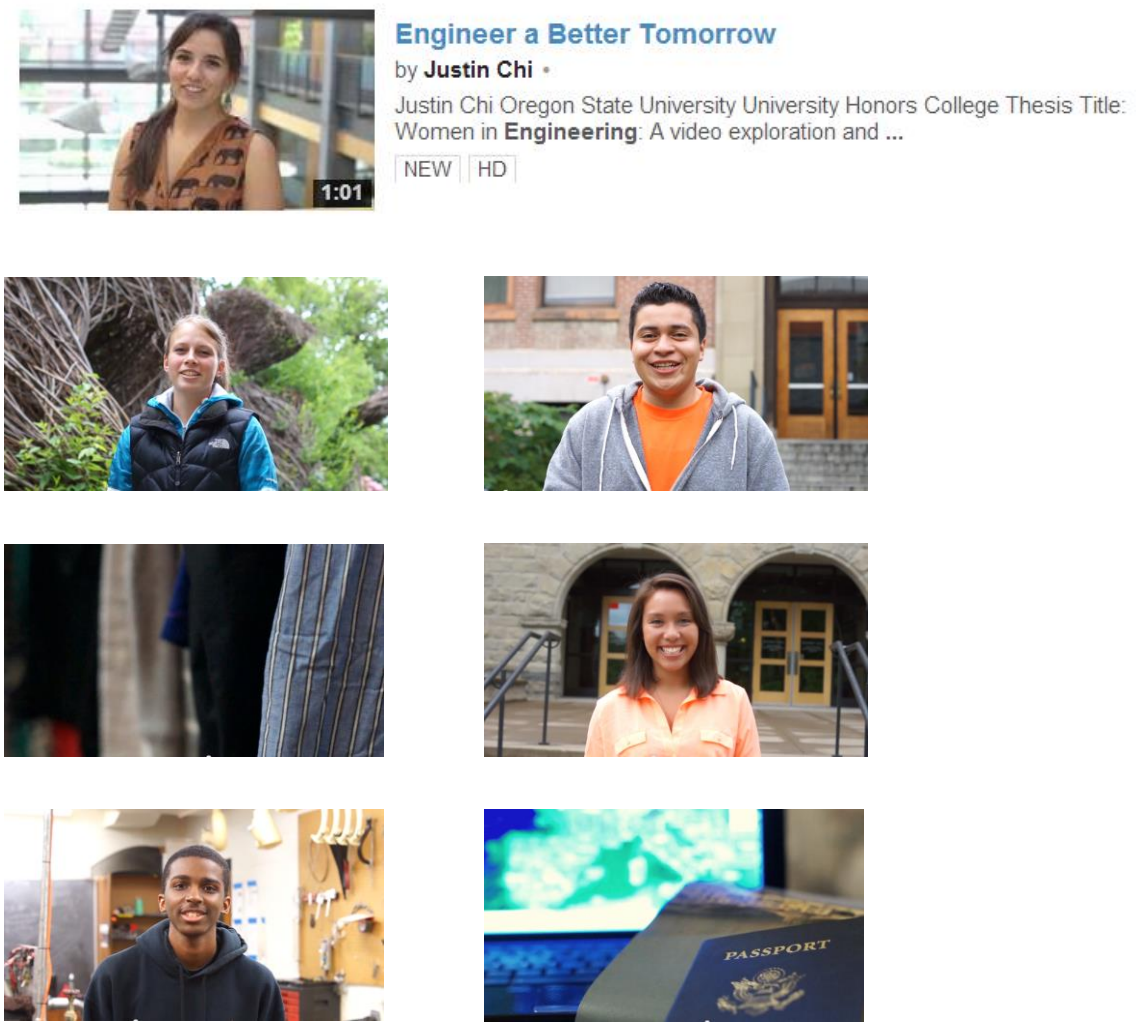

Figure 3: YouTube thumbnail for the video, "Engineer a Better Tomorrow" and stills taken from the various scenes in the video.

Each segment was spoken by a different student and matched to changing video scenes. Some of the sequences featured the student saying his or her line while other sequences used video overlay related to the statement. The video script developed is shown in Table 2.

Table 2: Script for the video, "Engineer a Better Tomorrow."

"I'm an engineer. I'm an engineer. I'm an engineer. I help people. I help animals. I help the environment. I'm a musician. I'm an athlete. I'm a scholar. I'm an artist. I'm a problem solver. I'm an innovator. I'm a dancer. And I'm also, an engineer. An engineer. An engineer. I love hiking. I love fashion. I love cooking. I love travelling. I love pets. I love movies. I love nature. I love sports. And I love that I can engineer all of that. Because I improve lives. Because I make a difference. Because I can change the world. And so can you."

The video ends with the fading in of "Engineer..." followed by the phrase "A Better Tomorrow" placed below the "Engineer…" text. This script was written with the help of interviewees to incorporate things that females identified that they enjoyed and that were related to engineering. Helping people, animals, and the environment were used at the beginning of the video to capture that women can help make the world a better place through engineering. The penultimate statements were then used to create positive motivation. The video ended with "and so can you" spoken by a female in an effort to empower girls and to raise awareness of the message that can be an engineer.

4.3 Video Feedback

Feedback was received from this video at the OSU University Honors College thesis fair. The majority of people who watched the video thought the video provided a positive and new direction for engineering recruitment videos. Additionally, some

viewers noted that this video stood out from previous recruitment videos they had viewed. Most viewers also noted and appreciated the diversity of the speakers and the message that no matter who you are or what you love, you can incorporate these passions with a career in engineering.

A common suggestion for the video was to provide more specifics on what engineering is about or what engineers do. The video does not provide any information on engineering as a profession or what an engineering program at a university would entail. In recognition of these issues, recommendations for how this video could be used are discussed next.

4.4 Recommendations

The OSU Engineering Ambassador program currently sends engineering students to high school STEM classes twice a year to give presentations about the field of engineering. These students use, as a basis for their presentation, a set of PowerPoint slides. These slides are included in Appendix F. Ambassadors create their own script around these slides.

The first slide asks “What do Engineers do?” followed by a second slide stating that “Engineers solve problems!” After the third slide, which lists all engineering programs at Oregon State University, the main topics of the presentation are shown. The slide title “What do Engineers do?” is answered below stating that engineers design, work in teams, help people, are sustainable, and have good jobs. The rest of the presentation describes each of these points and allows the ambassador to provide examples on why engineering is an attractive career path.

One topic this presentation does not cover is who are engineers? The video created as a result of this study is an important new component to add to the presentation. Because the video developed for this study is only one minute long, the integration of this new video within the larger ambassador set of slides would be an effective opening to the presentation and could also deter negative preconceptions about engineering before students hear about engineering with the presentation.

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Appendix A - Research Protocol

February 24, 2013

1. Protocol Title: Women in engineering: A video exploration and analysis of under-representation

PERSONNEL

2. Principal Investigator: Toni L. Doolen
3. Student Researcher: Justin Chi
4. Investigator Qualifications:
5. Dr. Toni Doolen is a Professor in the School of Mechanical, Industrial, and Manufacturing Engineering. Dr. Doolen has extensive experience in conducting research studies in the application of process improvement methodologies and innovation to improve organizational performance. She has over 50 publications in these areas and has supervised over 25 students in their graduate studies in this area. She has great familiarity with studies that involve human subjects, since nearly all of her research includes surveys and interviews of organizational members. In addition, she spent 11 years in manufacturing engineering and management roles at Hewlett-Packard Company. She received a BS in Electrical Engineering and in Materials Science and Engineering from Cornell University, an MS in Manufacturing Systems Engineering from Stanford University, and a Ph.D. in Industrial Engineering from Oregon State University.

   Justin Chi is an engineering student at OSU and has been involved in the Engineering Ambassador program for over 2 years. The program is funded and run by OSU Women in Engineering Director Ellen Momsen, Justin is an active member in the recruitment field as the video specialist.

6. Student Training and Oversight

   The PI has supervised multiple projects with documented interactions. The student researcher has completed training and will be supervised through weekly meetings and e-mail communication during interview sessions, analysis, and honors thesis preparation.

FUNDING

7. Sources of Support for this project (unfunded, pending, or awarded)
   This project is unfunded.

DESCRIPTION OF RESEARCH

8. Description of Research

   This project will seek to understand female under-representation in engineering programs and the resulting under-representation of women awarded undergraduate engineering degrees and in the workforce. Specifically, this research seeks to link negative pre-conceptions and misunderstandings of the field to those outcomes. Analysis of recruitment process and interviews with potential, current, and former engineering students and professionals will be used to study these topics and will provide a basis for the creation of a recruitment video. This research will be an Honors College thesis, and the video, one outcome of the research, will also be made available for use in the recruiting process. The recruitment video will include segments from interviews and footage of engineering-related activities, and will target young women in high school and college.

9. Background Justification

   In a society where equality is sought as the norm, occupational gender representation is still skewed in some disciplines. One field where gender equality in representation has not yet been achieved is engineering, whether in school or at the professional level. This imbalance is not only a potentially vicious cycle but also has numerous negative implications. Engineering is a topic and mindset that benefits from and sometimes requires diversity in background, experience, thought process, and other traits that the presence of both males and females would bring. Understanding and bridging the under-representation gap will improve engineering practice.

10. Subject Population

    Participants will be women, who are potential, current, or former engineering degree holders and women, who are looking to or are currently working in engineering related field.

    The target enrollment for this project is 50 adults, excluding prisoners, non-English speakers, non-literate participants, and persons lacking capacity to consent.

11. Consent Process

    The study presents no more than minimal risk of harm to subjects, thus written consent will be obtained after assessing eligibility for participating in the research. An explanation of research including potential risks and benefits of participation as well as contact information will be presented to individuals who express interest in the research. This will be done in person. A copy of the consent form (Appendix A) will be given to the potential participant. The student researcher will highlight sections 1-4 and then give the participant time to read the consent form and determine their desire to participate or not.

12. Eligibility Screening
    Participants must have interest, be currently engaged or have had experience in the engineering field to be eligible. If eligible, written informed consent will be obtained before interview questions are asked.

13. Methods and Procedures

    13.1 Subject Identification and Recruitment

    Study participants will be recruited via e-mail through connections that the student researcher has as a result of his role with the OSU ambassador program. Prospective and current engineering students will be identified using e-mail lists of organizations, which have high potential for eligible participants. Past and current engineers known from personal connections of the student researcher and principal investigator will be contacted through e-mail. Known colleagues who are eligible and have added knowledge in the field of recruitment will also be recruited through e-mail. The recruitment e-mail (Appendix B) will be sent until sufficient participants have been identified.

    13.2 Scheduling Interview

    Volunteers deemed eligible will be approached with interview scheduling options which all are catered for the ease and simplicity of the volunteer. This convenience includes and is not limited to location, timing, and transportation. Interviews will be held in the OSU Engineering Ambassador room, Batcheller 151, unless otherwise requested by interviewee. If unavailable, meeting rooms in Kelley Engineering Center, Kearney Hall, the OSU Valley Library, or the Memorial Union will be utilized.

    13.3 Interview

    Participations will first review and, if willing to participate, sign the consent form before an interviewing commences. The consent form includes information about the study, participate rights, confidentiality, and contact information. The interview process will use questions included in the interview question list (Appendix C) but not all questions may be asked. The specific questions will be asked dependent on the participate, particularly on relevance, time limitations, and/or general flow of a particular interview session. The interview and videography, will take no longer than one hour, and participants will be contacted after analysis and summary of all data to review and approve printing and publication of the collected information.

    13.4 Analysis and Interpretation

    Interview responses will be analyzed based on interviewee background (education, age group, experience, etc.). Interpretation of responses will be compared between the defining groups and also through comparisons to studies and statistics from national

and international surveys and polls. Determined weaknesses in the recruitment process as interpreted from interviews, that also match known areas for possible improvement, will be studied and incorporated into the recruitment video production.

14. Compensation

    There will be no compensation to participants.

15. Costs

    There will be no required cost to participants in the study. The student researcher and principal investigator will arrange meetings that are convenient to participant.

16. Anonymity or Confidentiality

    Names, engineering status, and video footage will be used only with consent. All documents and data will be stored on password-protected hard drive kept with student researcher during the study. Digital material will be kept in original format, physical copies and information will be digitized and securely disposed of, and all study material will be stored securely with the principal investigator for three years post study termination. Contact information will be stored only for contact and follow-up purposes and will not be linked to video or recorded materials.

17. Risks

    There are no discernible risks to participating individuals. Involvement is voluntary and participants will retain confidentiality unless consent is given. Volunteers will also be given the option to review contributions before publishing the study results or the video. There is a risk that information will be disclosed that identifies volunteers who wish to retain confidentiality.

18. Benefits

    There are no direct benefits to those who participate in the study. Anticipated benefits to society include an added recruitment device for women in engineering in upper education and a potential increase in interest and enrollment for women in engineering.

19. Assessment of Risk:Benefit ratio

    There are no discernible risks or benefits to the participants in this study.

20. Attachments

    Appendix C: Consent Form

    Appendix D: Recruitment E-mail

    Appendix E: Interview Questions

Appendix B - IRB Exemption Form

Institutional Review Board
Office of Research Integrity | Oregon State University
A312 Kerr Administration Building, Corvallis, OR 97331-2140
Telephone (541) 737-8008
irb@oregonstate.edu | http://oregonstate.edu/irb/

STUDY ID
5564

Notification Type	**EXEMPTION**		
Date of Notification	3/11/2013		
Study Title	Women in Engineering: A Video Exploration and Analysis of Underrepresentation		
Principal Investigator	Toni Doolen, PhD		
Study Team Members	Justin Chi		
Submission Type	Initial Application		
Level	Exempt	Category(ies)	2
Number of Participants	50 *Do not exceed this number without prior IRB approval*		
Funding Source	None	Proposal #	N/A
PI on Grant or Contract	N/A		

The above referenced study was reviewed by the OSU Institutional Review Board (IRB) and determined to be exempt from full board review.

Expiration Date: 3/10/2018
The exemption is valid for 5 years from the date of approval.

Annual renewals will not be required. If the research extends beyond the expiration date, the Investigator must request a new exemption. Investigators should submit a final report to the IRB if the project is completed prior to the 5 year term.

Documents included in this review:

- ☒ Protocol
- ☒ Consent forms
- ☐ Assent forms
- ☐ Alternative consent
- ☐ Letters of support
- ☒ Recruiting tools
- ☒ Test instruments
- ☐ Attachment A: Radiation
- ☐ Alternative assent
- ☐ Project revision(s)
- ☐ External IRB approvals
- ☐ Translated documents
- ☐ Attachment B: Human materials
- ☐ Grant/contract
- ☐ Other:

Comments:

Principal Investigator responsibilities:

- Amendments to this study must be submitted to the IRB for review prior to initiating the change. Amendments may include, but are not limited to, changes in funding, personnel, target enrollment, study population, study instruments, consent documents, recruitment material, sites of research, etc.
- All study team members should be kept informed of the status of the research.
- Reports of unanticipated problems involving risks to participants or others must be submitted to the IRB within three calendar days.
- The Principal Investigator is required to securely store all study related documents on the OSU campus for a minimum of three years post study termination.

Appendix C - Recruitment E-mail

Dear (Insert Name),

Your help is needed for an important research study. Justin Chi, an Oregon State University engineering student working on his Honors College thesis, is conducting research to better understand female under-representation in engineering programs and the resulting under-representation of women awarded undergraduate engineering degrees and in the workforce. This study, titled 'Women in engineering: A video exploration and analysis of under-representation,' specifically looks to link negative pre-conceptions and misunderstandings of the field. Interviews will be conducted with interested participants, which will culminate in a research paper and the production of an engineering recruitment video.

We are looking for women volunteers who are potential, current, or former engineering students, or women who are looking to or are currently working in engineering related fields. Volunteers will be interviewed and be given the option to retain confidentiality. These interview sessions will be video recorded and volunteers will also have the option to allow video clips to be used in the recruitment video production. The interview will take no longer than one hour and participants may stop involvement in the project at any time. Volunteers will be contacted to review their contributions before the thesis and video are published if desired.

If you are interested in volunteering, please contact Justin Chi at chij@onid.orst.edu to schedule an interview at your convenience. If you are not interested, but would like to help in other ways or have comments, please contact Justin as well.

If you have additional questions or comments, you may contact Dr. Toni Doolen, who is the principal investigator for this research, at toni.doolen@oregonstate.edu. If you have questions about your rights as a research subject, please contact the Oregon State University Institutional Review Board (IRB) at 541-737-8008 or by e-mail at irb@oregonstate.edu.

Kind regards,

Justin Chi, H.B.S. Candidate
School of Chemical, Biological and Environmental Engineering
Oregon State University

Appendix D - Consent Form

Project Title:	Women in engineering: A video exploration and analysis of under-representation
Principal Investigator:	Toni L. Doolen
Student Researcher:	Justin Chi
Version Date:	February 24, 2013

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1. WHY IS THIS STUDY BEING DONE?

You are being invited to take part in a research study to better understand the under-representation of women in the engineering field. More specifically, you will participate in an interview that aims to understand your thoughts on engineering as a degree pathway or as an occupational field, and how being a female has altered that course in any way.

The research will be used as the basis for an honors thesis. In addition, recorded video excerpts from the interview will be used to create a recruitment video.

2. WHY AM I BEING INVITED TO TAKE PART IN THIS STUDY?

You are being invited to take part in this study because you are either considering engineering as a future field of study or work or because you are currently engaged in engineering work.

3. WHAT WILL HAPPEN IF I TAKE PART IN THIS RESEARCH STUDY?

The study activities include a video-recorded interview regarding your viewpoints and thoughts on engineering. The interview will take no longer than one hour and you will have the option to release your video for use in the recruitment video. You will be contacted at the conclusion of the video production to review your contributions if desired.

_____ I agree to release my video, name, and engineering status (potential, student, professional) for subsequent use in the honors thesis and final video.
Initials

4. WHAT ARE THE RISKS AND POSSIBLE DISCOMFORTS OF THIS STUDY?

There are no discernible risks to participating individuals. Involvement and the release of your information are both voluntary, however, there is a risk that we could accidentally disclose information that identifies.

5. WHAT ARE THE BENEFITS OF THIS STUDY?

This study is not designed to benefit you directly but may benefit society in increasing interest and enrollment for women in engineering

6. WILL I BE PAID FOR BEING IN THIS STUDY?

You will not be paid for participating in this research study.

7. WHO WILL SEE THE INFORMATION I GIVE?

The information you provide during this research study will be kept confidential to the extent permitted by law unless otherwise consented for release. Recorded video from interview sessions may be used for the recruitment video, which will be viewable by the general public with limited distribution. Universities may include or use said video in recruitment processes that mass-distribute the video. Research records will be stored securely on a password-protected hard drive, and only researchers will have access to the records. The tapes will be frozen (unalterable but not deleted) at the conclusion of this project. Federal regulatory agencies and the Oregon State University Institutional Review Board (a committee that reviews and approves research studies) may inspect and copy records pertaining to this research. Some of these records could contain information that personally identifies you.

8. WHAT OTHER CHOICES DO I HAVE IF I DO NOT TAKE PART IN THIS STUDY?

Participation in this study is voluntary. If you decide to participate, you are free to withdraw at any time without penalty. You are free to skip any questions or prompts that you would prefer not to answer. If you choose to withdraw from this project before it ends, the researchers may keep information collected about you and this information may be included in study reports.

9. WHO DO I CONTACT IF I HAVE QUESTIONS?

If you have any questions about this research project, please contact Toni Doolen at (541) 737-5974 or by email at toni.doolen@oregonstate.edu or Justin Chi at (541) 740-6876 or by email at chij@onid.orst.edu.

If you have questions about your rights or welfare, please contact the Oregon State University Institutional Review Board (IRB) Office, at (541) 737-8008 or by email at IRB@oregonstate.edu

10. WHAT DOES MY SIGNATURE ON THIS CONSENT FORM MEAN?

Your signature indicates that this study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

(Signature and date)

Appendix E - Interview Questions

1. Why are you considering or why did you consider studying engineering?
2. What are the least and most attractive aspects of engineering to you?
3. Do you think that women are under-represented in the engineering field?
   If so, why and where do you see examples?
4. What do you think the ratio between genders is for undergraduate engineering at universities?
5. What do you think the ratio between genders is for engineering in the employment?
6. What do you think are the least and most attractive aspects of engineering to a high school or college student, more specifically for a woman?
7. How do you think women should be recruited into the engineering field?
8. What do you think is or isn't working with the recruitment of women in engineering?
9. If you were given one minute to convince a girl or young woman to study engineering, what would you say?
10. What stereotypes and thoughts come to mind when you hear the word engineer or engineering? More specifically, what people, qualities, skills, jobs, and conditions come to mind?
11. What stereotypes and thoughts do you think come to mind when girls in high school hear the word engineer or engineering?
12. Why do you think any previously mentioned stereotypes are or are not true?
13. How have these stereotypes and thoughts affected your decisions with engineering?
14. How might difficulties have presented themselves because of these stereotypes?
15. What do you think can be done to reverse stereotypes or pre-conceptions related to the engineering field?

Appendix F – OSU Engineering Ambassador HS Presentation

College of Engineering
Student Ambassadors

What do Engineers do?

Engineers solve problems!

"Scientists investigate that which already is; engineers create that which has never been." – Albert Einstein

Engineering at OSU

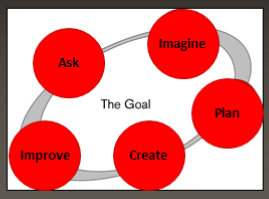
- Bioengineering
- Chemical Engineering
- Environmental Engineering
- Civil Engineering
- Construction Engineering Management
- Electrical & Computer Engineering
- Computer Science
- Industrial & Manufacturing Engr
- Mechanical Engineering
- Energy Engineering Management
- Nuclear Engineering
- Health Physics
- Ecological Engineering

What do Engineers do?

1. Engineers DESIGN
2. Engineers WORK IN TEAMS
3. Engineers HELP PEOPLE
4. Engineers ARE SUSTAINABLE
5. Engineers HAVE GOOD JOBS

1. Engineers DESIGN

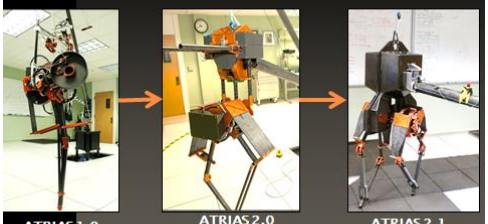
- ENGINEERING = MATH + SCIENCE + CREATIVITY
- Engineering Design Process



http://www.mos.org/sln/engineering_design.php

1. Engineers DESIGN

1. Engineers DESIGN



ATRIAS 1.0 Monopod
ATRIAS 2.0 Monopod
ATRIAS 2.1 Biped

2. Engineers WORK IN TEAMS

2. Engineers WORK IN TEAMS

- OSU Robotics Club Mars Rover

3. Engineers HELP PEOPLE

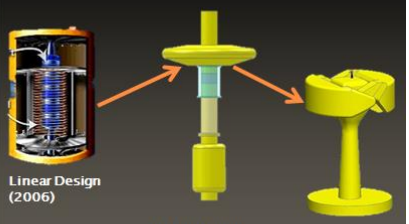
- O.H. Hinsdale Wave Research Laboratory

3. Engineers HELP PEOPLE

- Engineers without Borders
  Improving quality of life around the world through engineering projects

Lela, Kenya – Summer 2012

4. Engineers are SUSTAINABLE



4. Engineers are SUSTAINABLE

- Wave Energy Buoy

4. Engineers are SUSTAINABLE

5. Engineers HAVE GOOD JOBS

- For students:
  - Internships
  - Research
- For graduates:
  - Jobs in outdoors, education, law, business, medicine

5. Engineers HAVE GOOD JOBS

9 of the 10 highest paying jobs are in Engineering!

Average Starting Salaries in 2011

Chemical Engineering	$66,886
Nuclear Engineering	$63,900
Computer Science	$63,017
Computer Engineering	$61,200
Electrical Engineering	$60,800
Mechanical Engineering	$60,739
Industrial/Manufacturing Engineering	$59,200
Software Engineering	$56,200

http://betteronlinedegrees.com/online-bachelor-degrees-highest-paying-bachelors-degrees/
http://www.cnn.com/2011/LIVING/06/06/paying.jobs.2011.grads.cb/index.html

What do Engineers do?

1. Engineers DESIGN
2. Engineers WORK IN TEAMS
3. Engineers HELP PEOPLE
4. Engineers are SUSTAINABLE
5. Engineers HAVE GOOD JOBS

What you can do now!

- Take as many math and science classes as possible
- Get involved
- Summer camps
- Research on your own