ENGINEERING OUTREACH VIDEOS

Interactive Qualifying Project completed in partial fulfillment of the Bachelor of Science

Submitted to:
Professor Aaron Deskins and Professor Martha Cyr

Worcester Polytechnic Institute
Worcester, MA 01609
March 1st, 2016

_____*Franklin Alvarez*_____
Franklin Alvarez

_____*Bernardino Garay*_____
Bernardino Garay

_____*Ryan Lima*_____
Ryan Lima

_____*Maria Rios*_____
Maria Rios

_____*Raphael Sarkar*_____
Raphael Sarkar

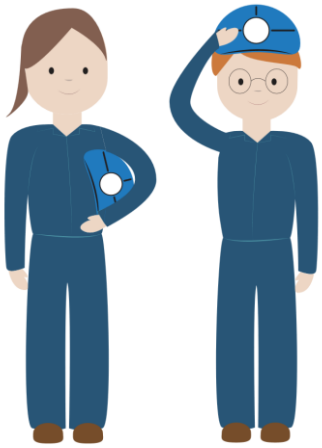

Table of Contents

Abstract

There is an increasing need for engineers, yet the number of students entering the field annually remains stagnant. Of all degrees awarded in 2013 only 4.7% were for engineering (Digest of Education Statistic 2013). Furthermore, few underrepresented students are entering the field. The purpose of this project was to promote engineering to young students by creating insightful videos. We researched the disincentive common amongst students and compiled a list of misconceptions we could dispel and messages we could convey in the short videos. Surveys were used to test four videos with middle/high school kids. It was concluded that short videos on engineering can have a positive impact on student's outlook of the career.

Acknowledgments

We would like to thanks our advisors, Martha Cyr and Aaron Deskins for guiding us through our project and giving us constructive criticism every step of the way. We would also like to thank WPI's Academic Technology Center for providing us with all of the resources and information needed when editing and creating videos. We are also grateful to all of the young professionals that volunteered to be interviewed and Suzanne Sontgerath from Admissions Office, Thomas Oliva from Forest Grove and Francis Graves, James Pignataro, John Roix, and Stephen Trombley from Grafton High School for allowing us to show our videos to their students. Finally, we would like to thank the Office of Student Activities for helping us contact recent graduate engineers for our project.

Authorship

All members of the group contributed equally to the completion of this project. The team separated into two teams to edit two videos each and all were involved in the research, survey development and testing of the videos. The bulk of the writing was performed by Ryan Lima, Maria Rios and Franklin Alvarez. The majority of data quantification and analysis was also performed by Bernardino Garay, Franklin Alvarez, and Raphael Sarkar. Compilation and organization of Appendix material was done by Bernardino Garay, Raphael Sarkar, and Maria Rios. Maria Rios and Raphael Sarkar also performed the majority of communication when contacting professionals and organizations. All members of the group contributed equally when editing the report and drafting an abstract.

1.0 Introduction

As time goes on, the need for engineers in the workforce will continue to grow to create innovations which help to sustain our way of life. However, just because there is a need doesn't mean there is a sufficient influx of graduates joining the field of engineering. In fact, of all college degrees awarded in the United States in 2013, only 4.7% were engineering degrees. This project sought to discover the reasons behind the lack of students going to school for engineering, and then use that information to create videos that would show a few fields of engineering in hopes of dispelling some of the misconceptions currently held by society about engineering as a career and to try and encourage students to think about engineering as a future career.

We started by defining the questions we wanted to answer. Why are there so few students entering college for engineering? Why are there even smaller percentages of women and minorities? How can we effectively change their views of engineers to create a more positive impression of the profession? How can we test the videos' efficacy to ensure we improve them moving forward? With these questions in mind, we started by gathering background data to find out about the current perceptions of engineering.

In our society, the average person typically misunderstands the work that is done by engineers. Though some have the idea of designers or creators, there are a majority that still tie engineering to contract working (Fralick et. al. 2008; Jordan and Snyder 2013; Capobianco et. al 2011; Montfor et. al 2013). Women tend to disregard engineering as vital to improving the standard of living, or helping people in the world as compared to doctors or nurses (Ing et. al 2014). Lastly, minorities tend to have fewer role models within engineering, making them less likely to even consider the field at all, which is an unfortunately self-perpetuating cycle (Ashby Plant et. al 2009).

To tackle these problems we found we came up with some key phrases or ideas we wanted to put in our videos which would both resolve any misunderstandings as well as provide a reason to think about engineering as a career. Such phrases included "Engineers make a world of difference", and "Engineers work to improve our health care system." Along with key phrases, we elected to try and put interviews with professionals in our videos, to give them more apparent credibility, as well as show students a few possible visual role models. We looked for minority and female professionals so we could show young students that not just white males are involved in engineering.

With our key ideas set, and interviews conducted, we created storyboards and began making videos. Our first video, on chemical engineering, took the longest to edit, going through several rounds to ensure we were getting all aspects of the process right, and then we subjected two versions of this video to testing via student viewing and surveys. The goal of the surveys was to gather data about middle school student conceptions of engineering. Initial data suggested that a few changes could be made to our surveys to make them more specific.

After the first round testing we continued with two new videos about electrical and mechanical, and tested them among a new student population with our new and improved surveys. The results from the surveys were compiled and discussed to draw conclusions about our overall video quality. We focused on their effectiveness in dispelling some of the misconceptions about engineering and sparking students' interest in the profession.

2.0 Background

In 2007, the NAE published *Rising Above the Gathering Storm,* which highlighted a critical need for well-trained engineers in order to maintain the US as an economically competitive nation. The report states that "knowledge acquired and applied by scientists and engineers provides the tools and systems that characterize modern culture and the raw materials for economic growth and development" (NAE 2007). However, of the total bachelor's degrees conferred by higher education institutions in 2013, only 4.7% were engineering degrees (Digest of Education Statistic 2013). And of the total engineering majors conferred, only 19.1% were earned by women, 4.3% by African Americans, and 9.3% by Hispanics (Yoder, 2014).

The establishment of outreach programs catered toward K-12 students has been a crucial component in the attempt to increase enrollment and diversity within engineering (Safferman et. al). Multiple studies have been performed to assess the effectiveness of different outreach programs and a number of examples exist which suggest they have been successful in increasing participants' knowledge and interest in the field or even encouraged them to enroll in post-secondary engineering programs (Weavers et al 2011; Anderson, Gilbride 2003; Nadelson, Callahan 2011). The structure of these outreach efforts vary widely and they can consist of short demonstration sessions that can expose participants to some aspects of engineering or they can be extensive, consisting of immersive programs that can last multiple weeks or even months (Nadelson and Callahan 2011).

The goal of this project is to provide an alternative outreach effort for young middle and high school students through videos about engineering and in this in depth review of the literature, evidence is presented that suggests that videos are as effective as "traditional" outreach programs (Wyss et al. 2012; Colson et al. 2014; Lopez-Martin et. al 2013). However, in order to produce videos that can spark students' interest in engineering, it was important to answer several questions beforehand that could offer guidance in developing an effective end product that could yield positive results. We looked into past literature to answer the following questions: *What perceptions do young students have about engineering? Why are students, particularly minority kids, discouraged from pursuing engineering? How can students be inspired to pursue engineering as a career? What kind of work and research has been done before in the area of outreach videos?*

2.1 Perceptions of Engineering by K-12 Students

Extensive research has been performed on K-12 students' perceptions of engineers and engineering. In a 2008 study, faculty members at the University of South Carolina utilized a research tool which assesses young students' images about scientists (Fralick et. al). This tool, known as the Draw a Scientist (DAS) test, was first administered by David Chambers of Deakin University in Australia, and was adapted by Fralick et. al to the Draw an Engineer (DAE) test, to assess students' perceptions of engineers (Chambers 1983; Fralick et. al 2008). Both the DAS and the DAE worksheets were administered to 1,600 middle school students from both urban and suburban schools in southeastern United States (Fralick et. al 2008).

The final DAE results showed that the most popular objects depicted in the drawings were passenger vehicles (19.8%) followed by civil structures (16.4%) and building tools (16.3%). The action depicted most was that of making (31.3%), followed by operating some kind of machinery (11.3%), and designing (10.1%). Other illustrated actions included explaining (2.2%), experimenting (1.9%) and observing (1.8%). As for location, the most popular depiction was an

engineer working outdoors (32.1%). In addition, the researchers noted that engineers were portrayed with no action or location more often than scientists were (Fralick et. al. 2008).

Therefore, from these results, Fralick et. al concluded that middle school students have inaccurate perceptions of engineers and engineering. In their analysis, they noted that engineers were mostly portrayed as the "worker bees" rather than individuals with significant mathematical and scientific knowledge. For the majority of the kids tested in this study, the engineers was analogous to a laborer and when comparing the DAS drawings to the DAE drawings, scientists were more likely to be portrayed as scholarly individuals as noted by the presence of books and thinking symbols. Fralick et. al also discussed the importance of students portraying engineers with no action more often that scientists were. This interesting result revealed that many students have a lack of perception about engineering instead of an inaccurate perception (Fralick et. al 2008).

Additional studies have arrived at similar conclusions. In one, around 400 students from grades 1 through 5 were administered DAEs and were interviewed. In analyzing their responses, it was found that the students mostly visualize engineers as mechanics, laborers, or technicians. The students' conceptions entailed engineers building, fixing, or making and using tools and engines. These conceptions were consistent in both urban and suburban students but it was interesting to note that suburban students associated an engineer with a laborer more frequently while suburban students associated engineers mostly with technicians (Capobianco et. al 2011).

These misconceptions are not exclusive to elementary and middle school students, however. In a study in which high school students were interviewed, the majority of students could not distinguish the role of engineers in a construction setting. The students would assume the engineers were responsible for "planning" but would describe them performing mechanistic tasks such as building and fixing. In fact, building and fixing things was the prominent component in the definition of engineering given by 19 of 27 interviewed students. In addition, the students struggled in differentiating engineers from scientists. Many would say that engineers work outdoors while scientists work indoors (Montfor et. al 2013).

Finally, another study explored the perception of students who participated in an after school engineering club run by a university based outreach program. All participants were from urban schools and while all 108 students were surveyed, only 40 were interviewed. However, qualitative analysis of both surveys and interviews revealed the same results. The top items described by the students as related to engineering were cars, bridges, buildings, and computers. Although these items relate to engineering in some way, the processes identified as being associated with engineering were still not completely reflective of the profession. These included repairing broken things building, creating or maintaining (Jordan and Snyder 2013).

In the literature, the misconceptions that K-12 students hold about engineers and engineering have been extensively documented along with the implications that these misconceptions hold. For example, both Fralick et. al and Jordan and Snyder discuss that inaccurate conceptions of what engineers are and what they do may lead to a decreased interest in the profession by students (Jordan and Snyder 2013; Fralick et. al 2008). In addition, these misconceptions can lead to the reinforcement of gender stereotyping in engineering. For example, in each of the studies mentioned above that made use of the DAE, more than half the students who drew a person drew a male engineer (Fralick et. al 2008; Capobianco et. al 2011).

Jordan and Snyder also emphasized that although the students they surveyed and interviewed were part of an outreach program, they still held misguided beliefs about engineering. They discuss that these misconceptions held by students are reinforced by outreach programs which devote "prolonged attention to production processes" without previously including a workshop or

lesson on problem definition, brainstorming, and problem solving (Jordan and Snyder 2013). In fact, a review of outreach curricula conducted by researchers from the National Academy of Engineering and the National Research Council found that "what passes for engineering education is not aligned with generally accepted ideas of the discipline of engineering" (Katehi et. al 2009).

2.2 Why Students are Discouraged from Pursuing Engineering

Some of the overarching reasons why students are discouraged from pursuing engineering include "low aptitude, lack of guidance, negative media presences and stereotypes, and ultimately a lack of knowledge about engineering" (Samuels, Seymour 2015). Of these factors, one of the most important is a limited understanding of the engineering profession (Safferman et al 2001). For example, as discussed previously, K-12 students tend to perceive engineers as laborers or technicians, instead of highly trained and well educated individuals and this can lead to a decreased interest in the profession (Jordan and Snyder 2013; Fralick et. al 2008; Montfor et. al 2013; Capobianco et. al 2011). It was also found from polling data that the public in general does not perceive engineers to be engaged with societal or community concerns (NAE 2008). Therefore, students who are highly interested in helping and serving others do not realize that they can do so through engineering (Anderson-Rowland et. al 2014).

The idea that engineers are not engaged with societal or community concerns particularly aids in discouraging girls from pursuing engineering. One study performed with middle school and high school students found that boys were more likely to be interested in engineering because they identified more with the aspect of designing and problem solving. On the other hand, girls were more likely to be interested in life sciences because they identified most with careers that can help the environment and people's health. Therefore, the researchers concluded that in order to attract more girls into engineering, it is important to introduce engineering as an "array of careers that can improve health, happiness, and make the world a better place" (Ing et. al 2014).

Another misconception that drives students away from the profession is that engineers are boring and dull. In an insightful piece written by an engineering professor at Indiana University it is discussed that the typical stereotype for an engineer is that of *Dilbert,* the dull office engineer portrayed in the popular newspaper comic strips. Images like these tend to reinforce the beliefs that engineers are predominantly male, non-communicative and unexciting (Yurtseven 2002).

A lack of information about the profession is also another reason why students are discouraged from pursuing engineering (Safferman et. al 2001; Anderson-Rowland et. al 2014). It was highlighted in the research performed by Fralick et. al that a large number of students had a lack of perception about engineering instead of an inaccurate one (Fralick et. al 2008). And in an interesting study performed by the Department of General Engineering at the University of Illinois in 2008, undergraduate female engineering students completed a survey in which they identified school, family, personal, and societal factors that could have potentially hindered their decision to pursue engineering. When it came to school factors, 49% of participants claimed that limited career information and exposure to engineering was the main obstacle in pursuing a career in engineering. When it came to personal factors, 45% of participants claimed that a lack of knowledge related to engineering careers was the main obstacle in pursuing engineering (Wentling and Camacho 2008).

In another study performed with both female and male students, including minority participants, students were asked to complete a survey evaluating their interest in several engineering fields. It was found that a large percentage of students responded with "I don't know what it is" when asked about engineering fields such as Aerospace, Biomedical and Civil. When comparing

these results by gender, female middle school and high school students responded with "I don't know what it is" more frequently than their male peers (Sandrin and Borror 2013). Finally, in another study, it was found that one of the top reasons why community college students do not have any interest in pursuing engineering is that they are not aware of the many career opportunities within the profession (Anderson-Rowland et. al 2013).

Another reason why students are discouraged from pursuing engineering is due to low self-efficacy beliefs in science and math. Self-efficacy refers to an individual's belief about his or her ability to perform certain actions or behaviors. If an individual performs well in a certain subject, they will expect to succeed in that same subject later on in life (Olson and Fagen 2007). In the study mentioned previously with community college students, the second top reason why the participants were not interested in pursuing engineering is because they thought they were not good enough at math. However, when comparing survey answers based on gender, female students were more likely to cite an inadequacy in math as the main reason for not pursuing engineering. (Anderson-Rowland et. al 2013). This supports the idea that female students tend to believe that they are less competent at math than their male peers. These negative self-efficacy beliefs tend to develop at an early age and as early as elementary school young girls frequently underestimate their math abilities even if their skills are typically equivalent to their male peers (Ashby Plant et. al 2009).

Negative self-efficacy beliefs play a role in discouraging all young students in general, however, not just girls. For example, one study performed by researchers at California Institute of Technology interviewed an ethnically and economically diverse group of high school students which at some point previously had shown interest in pursuing a career in engineering. When interviewing "lost potentials" or the students that no longer planned on studying engineering, it was found that one of the main reasons was their perception of math and science courses as hard. Struggling in these subjects serves as a major confidence shaker for young students (Aschbacher et. al 2010). The curriculum difficulty for engineering thus discourages many students from pursuing the profession, especially when there are alternate paths to decent technical jobs (Dimopoulos et. al 2011).

One final reason why students do not pursue engineering is that society in general fails to provide enough "visible role models" of individuals who have achieved success in engineering (Becker 2010). This is especially crucial since research has found that unless a student is directly related to someone who is an engineer, it is very unlikely that the student will have any role models that can expose them to the engineering world (Abbitt III, Carroll 1993). And in today's media-dominated society, the success of a few "winners" motivates more young students to pursue "lottery ticket careers" instead of more secure alternatives. An engineer probably earns higher than the average actor or musician but there are actors and musicians who earn millions of dollars per year. The high salaries and the media attention tend to elevate these professions and influence young people (Becker 2010). Engineers have little presence in mass media and if they do appear in media, they are portrayed as stereotyped caricatures such as *Dilbert* (Yurtseven 2002).

The need for relatable "visible role models" is especially important for girls and minority students. When girls are developing their gender identity, they tend to shy away from jobs that are portrayed as masculine such as engineering. This gender distinction is shaped largely by gender-stereotyped media such as TV programming and magazines. Prominent figures in media catered for females include doctors and lawyers while engineers are not considered (Becker 2010). In addition, a large source of positive self-efficacy beliefs in racial and ethnical minorities is observations of the experience of models that "one perceives as being similar to one-self." Therefore, seeing relatable examples of people that have succeeded in things that students want to achieve is a means of improving self-efficacy beliefs (Olson and Fagen 2007). However, the current underrepresentation of women and racial and ethnic minorities in engineering does not provide for these "visible role

models" and can serve to reinforce the impression that this career is not meant for them (Ashby Plant et. al 2009). As mentioned earlier, of the engineering majors conferred in 2013, only 19.1% were earned by women, 4.3% by African Americans, and 9.3% by Hispanics (Yoder 2014).

2.3 Encouraging Students to Pursue Engineering as a Career

As discussed previously, one major reason why students are discouraged from pursuing engineering is a lack of information about the profession (Safferman et. al 2001; Anderson-Rowland et. al 2014). Therefore in order to incite student's interest in engineering, it is crucial to provide relevant information about the career such as what engineers do, what different branches exist under engineering and what different career opportunities exist (Sandrin and Borror 2013; Anderson-Rowland et. al 2013). Providing students with information about what engineers actually do at an early age is especially crucial in order to dispel many of the misconceptions about engineers and engineering that young students have. As mentioned previously, young middle school and even high school students tend to associate engineering with laborers, mechanics and technicians and these misconceptions may lead to a decreased interest in the profession (Jordan and Snyder 2013; Fralick et. al 2008). Therefore, it is important to avoid what many outreach efforts mistakenly do, which is give too much emphasis to the production aspect of engineering and not the problem solving and design aspects of the profession (Jordan and Snyder 2013).

In order to encourage students to pursue engineering, it is also important to dispel many of the negative stereotypes held by the general public (Metz 2006). It is important to provide images of engineers to young students that stray significantly from characters such as *Dilbert*. *Dilbert* reinforces the stereotype of the frustrated engineer who is locked in a cubicle and who is non-communicative, dull and a loner. However, engineers are people who are intelligent, articulate, conscientious and very capable (Yurtseven 2002). Dispelling stereotypes is also extremely important in encouraging girls to pursue engineering since it is typically stereotyped as an unfeminine profession that is object oriented instead of people oriented (Ashby Plant et. al 2009).

In encouraging girls to pursue engineering, it is also important to present engineering as an "an array of careers that can improve health, happiness, and make the world a better place." This is because research has found that young girls tend to identify with careers that can help the environment and people's health (Ing et. al 2014). However, in a study published in 2014, it was found that in general, students who hope to address sustainability issues are more likely to be interested in pursuing engineering. Yet, they did find some differences in interest among the students. For example, results showed that students who wish to address sustainability issues related to climate change, energy, water supply, and environmental pollution were more likely to be interested in pursuing engineering. On the other hand, students who wished to address issues such as opportunities for minorities and women, poverty, and disease were less likely to be interested in pursuing engineering. The researchers noted that if students were hoping to address sustainability-related problems with expected outcomes that have obvious human relevance, then they were less likely to show interest in pursuing engineering. But interestingly enough, they did find that students who perceived "improving quality of life" and "saving lives" as associated with engineering were more likely to be interested in pursuing a career in engineering. Therefore, the researchers concluded that in order to incite students' interest in the profession it is important to draw a connection between sustainability problems and how engineers are a crucial component in solving them (Klotz et. al 2014).

However, as discussed previously, the image of engineers is not necessarily connected to societal aspects such as sustainability issues since the general public does not perceive engineers to be engaged with societal or community concerns (NAE 2008). Therefore, it is important to present an improved image of engineers to young students, one that demonstrates a professional who collaborates with others with one goal in mind: the advancement of society and the solution of some of the issues facing our world today. And one important way of presenting to middle school and high school students a positive image of engineers and engineering is through media (Samuels, Seymour 2005). A groundbreaking study performed by the National Academy of Engineering titled *Changing the Conversation,* administered surveys to 3,600 participants in order to test several messages and taglines about engineering that the researchers had developed. The goals of the study was to find ways to improve the image of engineers through "media and marketing campaigns" to address the misconception that engineers are not involved with societal or community concerns. Of the tested messages, the most popular included "engineers make a world of difference," "engineers are creative problem solvers," and "engineering is essential to our health, happiness, and safety" (NAE 2008).

The researchers also examined which phrases were most popular based on gender. For example, although both boys and girls identified most with the message "engineering makes a world of difference," the second most popular message among boys was "engineers are creative problem solvers" while for girls it was "engineering is essential to our health, happiness, and safety" (NAE 2008). This result supports the observation made in the research discussed previously by Ing et. al. Boys are interested in careers that allow them to solve problems while girls are interested in careers in which the main goal is to help people (Ing et.al 2014). In their final recommendations, the NAE researchers discussed how modified versions of these messages should be used throughout any outreach effort catered to young students and the general public (NAE 2008).

Another important way of encouraging students to pursue engineering, especially girls and minority students, is by providing "visible role models" (Becker 2010). Social cognitive career theory (SCCT) is a theoretical framework that explores the social and psychological factors that incite personal interest and lead to choices in higher education and future careers. Self-efficacy, which was touched upon previously, is a key component of this theory. One of the main sources of self-efficacy beliefs, especially among girls and minority students, is the observation of the experience of models, especially models that "one perceives as being similar to oneself." It has been found that when students observe relatable models succeed at things that they would like to do in the future, their self-efficacy beliefs about that particular field or specific subjects, can improve. An additional way to improve students' self-efficacy beliefs also includes the use of positive social messages that encourage participation in a specific activity. It is crucial to let all students know, but particularly girls and minority students, that although there may be obstacles, it is still possible for them to pursue a career in engineering. Showing them relatable role models or "visual examples" can significantly aid in this (Olson and Fagen 2007).

Finally, another way of inciting student's interest in engineering is to avoid an over-emphasis in science and math in outreach programs. In their literature review for *Changing the Conversation,* the National Academy of Engineering found that outreach efforts that overly emphasize math and science in their marketing are more likely to scare off scaring young children than attract them. However, a strong basis in science and math is still a necessary skill that all engineers possess. What the NAE researchers suggest is following the example of the medical profession when it comes to changing messages of engineering and improving the overall image of engineers. A medical doctor still relies heavily on a vast and detailed science foundation, but the profession is not marketed to students by emphasizing that they will have to learn subjects such as organic chemistry. Instead,

physicians are promoted as individual who bring relief and cures to humans all over the world (NAE 2008).

2.4 Previous Work and Research on Outreach Videos

Before exploring other information on outreach videos, it was first important to determine whether there was any evidence indicating that videos are an effective outreach method. In one study, the researchers set out to test whether showing a 10 min video about engineering to 5th and 8th grade students would change their perception about engineering. The video shown to the students was part of a series created for the National Engineers Week event in 2013 sponsored by *DiscoverE* and it presented adolescents speaking about their experiences with engineering and students, including girls, working with an engineer to purify water. The researchers first segregated students by gender and had them respond to a questionnaire about engineering. Following the questionnaire, test-group students were shown the 10 minute video while control group students were returned to their classrooms. A majority of the 5th grade girls exposed to the video reported feeling differently about engineering while almost half of them had reported learning something new about engineering. Participants who saw the video were also more likely to agree with the statements "engineers design things that help the environment" and "engineers are women" than students from the control group. However, the researchers noted that after watching the video, the number of students who reported an interest in pursuing engineering as a career was not overwhelmingly positive. Regardless, the video was still effective in "eliciting the student's ideas and perceptions about engineering and to prompt the students to think about engineering as a future career possibility" (Jennings et. al 2014).

In another study, interviews with engineers and scientists were recorded and presented to sixth and eighth grade students in order to see whether these interview videos were an effective way of inciting interest in STEM careers among young students. As in the previously discussed study, both a test group and control group were used in this experiment. Final analyses of surveys completed before and after video exposure lead the researchers to conclude that the students who were exposed to the video showed a definite increase in interest in engineering and other STEM careers compared to the control group (Wyss et al. 2012).

Finally, in another interesting study, researchers developed educational videos led by engineers in order to provide young students with insight on what engineering is and what engineers do. Results showed that there was a significant gain in understanding of the work of an engineer across all the surveyed students after exposure to the videos. Students who were exposed to just the engineer-led videos and had not had any time with an engineer in the classroom, also showed a significant increase in their desire to pursue engineering-related careers. Thus the researchers concluded that these videos have the potential to positively influence elementary students' engineering career awareness. The researchers also discussed how videos suggest a viable and broader impact model with the potential to encourage and broaden participation of individuals who are underrepresented in STEM education and the workforce (Colston et al. 2014).

Therefore, it has been found in the literature that the use of videos as an outreach method has a positive influence in young students since they have been shown to increase interest in engineering and other STM careers (Wyss et al. 2012; Colson et al. 2014). They have also been shown to increase students' understanding of the engineering career and the work performed by engineers, and to dispel some stereotypes of the profession that young students are exposed to such as engineers being only male (Colson et. al 2014; Jennings et. al 2014). Perhaps more direct evidence

of videos' effectiveness was demonstrated by the School of Industrial and Telecommunications Engineering at the Public University of Navarre, Spain. The department found that their several outreach methods had collectively increased program enrollment by 10%. One of these outreach efforts consisted web sources that included videos that describe degrees offered by the School of Engineering and feature profiles of working professionals and insights into their daily work. In evaluating the effectiveness of each individual outreach program, the researchers found that around 20% of recruited individuals in the years 2008 and 2009 received all of their information about degree and career options through the web videos (Lopez-Martin et. al 2013).

After evaluating the effectiveness of outreach videos it was then relevant to explore what kind of work had already been performed in this particular area. This included exploring and analyzing individual video examples and exploring larger web resource efforts which contained a large component of educational and outreach videos for students. One large web effort that can serve as reference for this project is the *Engineering: Go for It* website. The website is supported by the American Society for Engineering Education and it provides multiple resources that are primarily catered towards middle school and high school students. The resources of interest were video interviews with professional engineers, and video interviews with undergraduate engineering students. When analyzing the format and content of the videos, several points were made. In the videos with professional engineers, care was taken to include a varied selection of professionals based on gender and racial and ethnic backgrounds. The same was seen in the series of videos in which undergraduate students were interviewed. However, one weakness found in the videos with professional engineers is that they do not put much effort into trying to give students an understanding about what the specific field of engineering actually is. The website provides information about what engineering is and what engineers do in writing and then focuses the videos with professionals to give specific examples. However, for this project, it is intended to include this type of information in the videos themselves ("Engineering; Go for It").

Although the videos with professionals and students in this particular resource were not as informative as they should have been, they did succeed in providing "visible role models" that a varied population of students can relate to. They also succeeded in dispelling many of the stereotypes about engineering described in the previous sections. The videos with student interview also dealt with self-efficacy issues. For example, many of the students spoke about how they struggled with math and science but eventually they realized they could still succeed in the world of engineering. However, the overall style of the student interview videos was poor and more effort could have been made to make them attractive to a younger audience ("Engineering: Go for It").

Another large effort that can serve as reference for this project is the *Engineer Your Life* website. This outreach website is catered for girls and it includes video interviews with female engineers and written descriptions about professional female engineers. These video interviews not only provide "visible role models" for young female students, but they also focus on how the problem solving aspect of an engineer's career helps improve health, the community and creativity. The videos also focus on how engineering is a collaborative and social career. The interviewed engineers also share their passions about their work and their inspirations for pursuing engineering ("Engineer Your Life"). All of these important aspects of these videos are things that as described in the sections above, should be included in this project in order to encourage young students to pursue engineering. However, the goal of this project is to be all-inclusive and both male and female "visual role models" from different race and ethnic backgrounds would be included. In addition, a lot more emphasis would be placed on dispelling some of the misconception that students hold that were discussed previously.

A series of videos were presented in cooperation with the Boeing Corporation in the *PBS Learning Media* website. The series of videos does not include an overview video about what engineering is but they do provide profiles on multiple mechanical and aerospace engineers that work for Boeing Corporation. The videos are excellent at dispelling the many stereotypes about engineering since they demonstrate the collaborative aspect of the career. The videos are also effective in providing relatable "visible role models" for a wide array of young students. For example, several of the interviewed engineers described how their parents had little secondary education themselves but that did not stop them from pursuing a career in engineering. In fact this served as motivation for a lot of them ("Aerospace Engineering").

An outreach effort that is more aligned with the end goal of this project is a YouTube channel by the University of Newcastle Australia. The channel has a series of videos about engineering and the one analyzed closely is titled "What is Engineering?" which gives a brief overview on what engineering is and what engineers do (UON). The video has excellent quality and it was well formatted with a younger audience in mind by keeping it interesting with animations and lettering on the frames. However, the video does not really touch on the many different fields of engineering and their different career options. Instead it emphasize mostly on the fact that engineering as a whole is about problem solving. Although it is mentioned that engineers are important for making the world a better place, the examples they focus on do not necessarily involve issues such as climate change or health, two fields in which engineers are extremely important. They also emphasize tremendously the need for science and math which was found in *Changing the Conversation* to be more likely to scare off young students than attract them.

Another video that was closely analyzed is titled "Why Study Engineering." The video has no background narrator but it does include some interviews with professional engineers. The video focuses on how engineers are crucial for solving environmental and social problems but despite its length of five minutes, it does not go into much detail about what engineers specifically do or the many fields of engineering. Instead, the video wants to encourage students to pursue engineering by mostly showing the technologies that engineers work on ("Why Study Engineering?"). However, as discussed previously, encouraging young students to pursue engineering must involve providing them with relevant information to dispel stereotypes and correct any misconceptions.

One final video analyzed was titled "What's an Engineer? Crash Course Kids #12.1." This video goes into more detail about what an engineer is. It also has excellent style that is catered for elementary and middle school students which include interesting animations and text that follows along with discussion in order to reinforce important concepts. However, certain aspects of the video are not effective in dispelling some of the misconceptions that young students have about engineers. For example, when discussing what a civil engineer is, the text that appears in the screen describes them as peoples who "construct buildings, roads and bridges." Statements like these are prone to reinforce the image that are majority of young students have of engineers which is of laborers and construction workers (Fralick et. al 2008; Jordan and Snyder 2013). Although briefly touched upon, the video also does not go into much detail on how engineering is essential to our health and happiness.

Many more videos were evaluated for reference but a full discussion of these was not included in this section. A list of all the videos evaluated and their respective qualities is included in Appendix A. In addition to evaluating video examples, other information was gathered on what makes any kind of educational video effective for younger students in terms of structure and technical style. The purpose of gathering this information is to develop a structure and technical style in the videos that maximizes student engagement.

The most relevant information gathered about educational videos concerns video length. Research in which 6.9 million video watching sessions were analyzed, it was found that when videos are less than six minutes long, there is almost a 100% "median engagement time." This means that the vast majority of students would watch the video in its entirety. However, student engagement decreased when videos became longer and it was around 50% when videos were from nine to twelve minutes. When the length was increased from twelve minutes, student engagement decreased even further to 20%. Therefore, in order to maximize median engagement time for a video, it is important to keep length at or below six minutes (Gou et al. 2014; Brame 2015). In addition, it was also found that median engagement time depended on the narrator's speaking rate. As speaking rate increased, engagement also increased. Although it can be tempting to go slow in order for material to stick, this is more likely to bore students (Guo et al. 2014)

3.0 Methodology

The goal of this IQP was to inspire middle and high school students to pursue the various fields of engineering through informative videos that dispel misunderstandings about engineers. Engineering opportunities are on the rise with company growths and the modern world's increasing need for innovative thinkers, causing a significant need for students to pursue engineering. However, the majority of young students do not fully understand the responsibilities of the profession, causing lack of engineers coming into the workplace. In general, their misconceptions lead them to visualize engineers as mechanics, laborers or technicians (Fralick et. al. 2008; Jordan and Snyder 2013; Capobianco et. al 2011; Montfor et. al 2013). In addition, other factors such as the academic demand of the profession, a lack of "visible role models" and the stereotype of engineers as boring and antisocial aid in students not pursuing the career (Dimopoulos et. al 2011; Becker 2010; Yurtseven 2002). Our videos will be assessed based on the following factors:

1. Video Content and Message
2. Survey Results and General Student Feedback.

In addition to discussing how the videos will be assessed, this section will also delve into the general process of video production and interviews with professionals. Figure 3.1 presents a brief visual outlining the main steps performed to complete this project which are discussed in detail here.

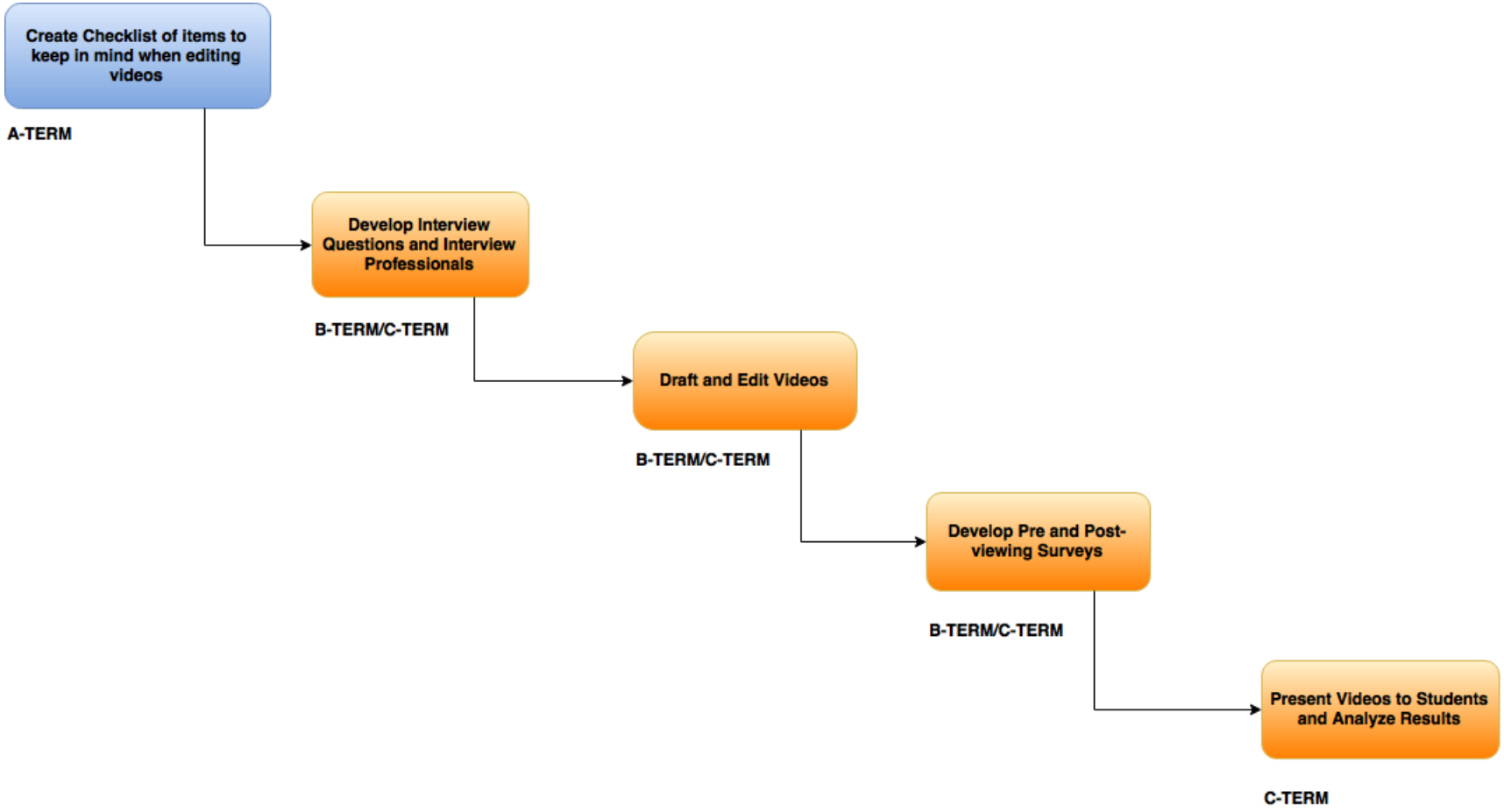

Figure 3.1: Visual representation of the steps described in Methodology section taken to complete this project including academic terms is which each step was performed.

3.1 Video Content and Message

The first basis by which our videos were assessed was by their content and message, tailored to the information gathered in the literature review. A checklist was created with which we could assess the expected effectiveness of the produced videos. This ties back to the main questions posed such as why students are discouraged from pursuing engineering and how students can be inspired to venture into engineering as their careers. This checklist is included below:

Video Message Checklist

1. Show students what engineers actually do.
2. Dispel perception that engineering requires extreme intelligence
3. Demonstrate how many other skills are required for engineering such as creativity, teamwork, communication, time management, etc.
4. Show that engineers are important in solving today's real problems such as quality of health and renewable energy.
5. Show that engineers are not boring but they are in fact enthusiastic and passionate about their work.
6. Present "visual" role-models of engineers.
7. Produce videos that are shorted than six minutes.

The first point on the list was the current perception of engineering in the eyes of young students, as well as adults, today. Prominently, engineers and the work they do is greatly misunderstood by both young students and adults (Dimopoulos et. al 2011; Becker 2010; Yurtseven 2002). Therefore, to dispel misconceptions of engineering in the minds of everyone who sees our videos, a solid foundation was built around what engineers do, both generally and specifically within their fields. To do this, information in the videos was included about what engineers do and the many different applications in which they can work. Including interviewees with background experience working on projects was also critical in showing just what kind of work engineers in their field do. This was also done by providing visual examples of products that engineers design or help produce like plastics for chemical engineers, electronic devices such as smartphones and computers for electrical engineers, and drones and aircrafts for mechanical engineers.

The next point on the list was the perception that engineering requires the ability to understand difficult mathematics. In our videos, we presented engineering as an approachable subject by everyone and not just by a gifted few. When discussing the skills used by engineers, it was explained that the mathematics may be important, but this skill as well as the many others acquired by engineers are learned gradually, with chances to practice in school. It was also necessary to show in our videos that in order to be a successful engineer, many other skills are required that stretch outside of the academic world. These skills include teamwork, communication, time management, creativity, thinking outside of the box and many more. This was done by including interview segments in which professionals discussed who they thought could become an engineer and what skills they thought were required to be a good engineer. For example, in the electrical engineering video, one of the interviewed professional discusses that "in the field, life is not always about being able to do the math [...] while it's important to understand how the math works, I don't think it will make or break you when you get to that setting. It is a whole set of other soft skills that are more important such as the attention to detail, ingenuity and being clever and creative."

In addition, the videos produced for this project did not contain an emphasis on science and mathematics. Information obtained from the literature review found that outreach efforts that overly emphasize math and science in their marketing are more likely to discourage young students than to interest them. Instead, our videos emphasized more on the positive impact that engineers have in society and not on the specific academic skills that they have to learn. Thus another large portion of our videos revolved around message number four. A big part of this included connecting the work of engineers to medicine. For example, in one of the chemical engineering videos, information such as "chemical engineers can also apply their knowledge in other fields such as biomedical engineering. For example, they can apply the concept of fluid mechanics to help understand biological processes to help in the production of medical drugs and devices," was included.

This was particularly important since women generally like to enter career paths which they believe will make an important difference in the world, or will help others (Ing et. al 2014). In fact, other research has pointed out that this urge to make a difference in the world is also shared by young men as well (Klotz et. al 2014). In order to make effective outreach videos, clear examples of work that engineers do every day that have a direct effect on the wellbeing of people and the planet were included. Instead of delving deep into the aspects of problem solving, examples such as the one described previously and "electrical engineers play a big role in health and medicine thanks to products such as heart rate and blood pressure monitors and other devices that allow doctors to easily take care of their patients and to diagnose diseases" were included.

It was also important that our videos dispel the negative stereotype that engineers are boring by presenting visual examples of engineers that stray from the stereotypical *Dilbert* character which reinforces the image of a frustrated engineer locked in a cubicle. Thus our videos contained images of young, happy and engaged professionals that reflect what an engineer actually is: an intelligent, articulate, conscientious and very capable individual (Yurtseven 2002). Presenting interviews with young engineers in our videos would not only provide "visible role models", but it would aid in dispelling many of these stereotypes. Through these interviews, the videos showed that engineers are enthusiastic and passionate about their work. If the interviewee presented an energetic presence on camera this aided our videos in conveying this message. Presenting images of female engineers and including footage of female interviewees in the videos also dispelled common stereotypes of the profession being unfeminine (Ashby Plant et. al 2009). Below are several examples of the varied images of engineers used in the videos.

Figure 3.2: Example images of engineers at work used in the videos.

The effectiveness of the videos produced throughout the project largely depended on whether the items on this checklist were met. A final item in this list was concerned with the length of the videos. As touched upon in the background, when educational videos are less than six minutes long, the vast majority of students will watch it to completion. Therefore the videos produced in this project were shorter than six minutes in length (Guo et al. 2014; Brame 2015). Keeping the narration rate in the video at a slightly faster than normal rate would also increase engagement among students (Guo et. al 2014).

3.2 Survey Results and General Student Feedback

In order to evaluate the effectiveness of our videos, a survey was created to ask students their opinion about a particular video and its information. The purpose of the survey was to get a general idea of what students thought of the videos they were shown and based on the results, make any changes to improve future videos. The survey consisted of before video and after video questions. The before questions asked the students what they think about engineers and their interest in engineering. The post viewing questions asked the students once more what they think about engineers and their interest in engineering and it also asked them to give more descriptive opinions on certain stylistic and informative elements of the videos. It was our intention to use pre and post viewing surveys to assess whether the students' opinions on engineering changed after watching a particular video and to see what changes could be made to make a better product.

To keep the survey simple, most questions involved choosing between "strongly agree", "agree", "disagree", or "strongly disagree". These questions were primarily gauged to determine what students think about engineers and whether they show any interest in pursuing a career in

engineering. Then, questions such as "You have to be extremely good in math and science to become an engineer." were added to determine whether students agree with some of the common notions about engineering discussed in the background. If they felt that only a select few people could take up the title of engineer, they may not be interested if they are less confident in their own abilities. We then added a few short answer questions to the post survey revolving around things they would like to see added or removed from the videos whether it is information about the field or other content such as images or interview footage. The open ended questions also provided general impressions of the video. From this we could make more informed decisions when making future videos. A complete list of survey questions is included below.

Pre-Survey

Answer the following questions by checking a box.

- Q1. Engineering is a fun job
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree
- Q2. Engineers are important in solving today's real world problems such as quality of health-care and renewable energy
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q3. Engineers are problem solvers:
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q4. You have to be extremely good in math and science to become an engineer
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q5. I am interested in becoming an engineer:
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

Post-Survey

Answer the following questions by checking a box.

- Q1. Engineering is a fun job
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree
- Q2. Engineers are important in solving today's real world problems such as quality of health care and renewable energy
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q3. Engineers are problem solvers:
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q4. You have to be extremely good in math and science to become an engineer
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q5. I am interested in becoming an engineer:
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q6. My overall feelings about the video are (check all that apply)
  ☐It was engaging and entertaining ☐It was boring ☐It was educational
  ☐It was too long ☐It was too short

Short Answer Questions

- Q7. Which images presented in the video did you find most interesting and/or inspiring?
- Q8. Which images presented in the video did you not find interesting and/or inspiring?
- Q9. Was there any part of the video that you found confusing
- Q10. What were your thoughts on the professionals? Were they informative?
- Q11. Did you find the video informative and useful? What information did you think was missing from the video?
- Q12. What do you think a Chemical engineer does?
- Q13. Would you like to see more videos like this about other engineering fields? If yes, rank the engineering fields from 1-4 based on what you would like to see most.

__ Electrical Engineering __Biomedical Engineering __Civil Engineering __Mechanical Engineering

- Q14. Which of the two videos would you recommend to your friends?

Figure 3.2: Pre and Post Video Viewing Surveys Administered to High School and Middle School Students for Chemical Engineering Video

Before the first round of testing, the group split up into two editing teams. Each team scripted and edited a video about chemical engineering independently. The purpose of this was to create two videos with different information, images and editing techniques to see which approach was more effective. These two videos were then shown to high school students, both boys and girls, ranging from grades 9 to 12. The classes in which the videos were shown included two honors chemistry classes, three manufacturing classes, one environmental science class and the school band. The variety of classes was chosen in the hopes of gathering a sample population that was varied in interests and not necessarily biased about engineering. For each class, only one version of the video was shown and groups that watched video one and groups that watched video two were chosen at random. However, they were presented to different classes in a manner in which an approximately equal number of students viewed each.

The "strongly agree" to "strongly disagree" scale questions in the pre- and post-viewing surveys were quantitatively analyzed by simply tallying how many students responded with "strongly agree", "agree", "disagree" and "strongly disagree" and presenting total response percentages. On the other hand, the short answer questions on the post survey were qualitatively evaluated by reading the responses for each question and summarizing the overall response and what the majority opinion was if there was one.

The purpose of this initial experiment was to take two completely different videos about chemical engineering, different in both the information they presented and other stylistic elements such as images, music and interview segments included, to see which one gathered a more positive response. The video with the most positive response based on survey analysis was then presented at a second round of testing which took place at an outreach event, STEM Saturdays, hosted for young middle school students by Worcester Polytechnic Institute (WPI). The group consisted of an approximately equal number of boys and girls all in the 7th grade. As done previously, the students answered both the pre and post viewing surveys and they were analyzed using the same quantitative and qualitative methods discussed above.

Using the feedback gathered from these two testing rounds, videos for both electrical and mechanical engineering were scripted and edited. However, as the data gathered for the chemical engineering videos using these pre- and post-viewing surveys was being analyzed, it became clear that it was necessary to provide a better means of quantifying whether or not the created videos increased the students' interest in engineering and to try and find reasons as to why or why not. In other words, we wanted to better know in numbers whether there was any change at all in the students' interest in engineering. We wanted to know why the change was positive or negative or why there was no change at all. Therefore, after the first two rounds of testing, an improved set of pre and post viewing surveys were developed to assess the mechanical and electrical engineering videos. The main strategy for these surveys was adding questions that had students explain what aspects of the video caused any change in opinion about engineering and adding questions that could better quantize reasons why students are not interested in the profession.

In order to try and quantize the reason why perhaps students are not interested in engineering, the question "What qualities are most important in engineers?" was added. It was our intention to better quantify any change in opinion on what students think of engineers from before to after watching the videos. This was also attempted in the previous survey but when analyzing results gathered for the video on chemical engineering, it was found that just the questions included in the pre and post surveys were not enough to gain a clear picture of any change.

For the improved post viewing survey, the statement "After viewing this video, I am more interested in finding out more about a career in engineering (all fields, not just the one in the video you watched)" was included. The students had the option of answering with "yes", "no" or "unchanged" and then they were asked to provide in writing which aspects of the video influenced their choice. If the student felt that they were more interested in learning more about engineering after watching the video, then perhaps it was because of a particular image or message presented in the video. With this question, it is our intention to create a better picture of whether there was any change in the students' interest in engineering after watching the video, whether this change was positive or negative and why.

A number of questions that were included in the first version of the pre and post viewing surveys were also removed since it was determined by the group that they would not provide any new or different information. For example, the question that tested whether the video was too long or too short was removed since the gathered data revealed that the initially determined length of less than six minutes was just right for the majority of surveyed students as discussed in the results. Other questions that were found to provide no useful information were also removed such as the question that asked the students which version of the chemical engineering video they would recommend to a friend. In the previous rounds of testing, the students were told to ignore this question since only one version of the chemical engineering video was presented to each group. In addition, it was not necessary for us to gather information from this question in the next rounds of testing since we were no longer testing two video versions of the same topic. The question that

asked students to rank engineering fields based on interest was also removed. The new surveys are included below.

Pre and Post Video Viewing Surveys Administered to High School and Middle School Students for Electrical and Mechanical Engineering Videos

Pre-survey

Answer the following questions by checking a box.

- Q1.1 Engineering is a fun job
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q2.1 Engineers are important in solving today's real world problems such as quality of health-care and renewable energy
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q3.1 You have to be extremely good in math and science to become an engineer
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q4.1 I am interested in becoming an engineer:
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q5.1 What qualities are most important in engineers? (Pick 3)

  ☐Teamwork ☐Strong in Mathematics ☐ Communication

  ☐Individual problem solver ☐ Leadership ☐Time Management

  ☐Creativity ☐Strong in Science ☐ Working at a computer all day

  ☐Strong Writing ☐High IQ ☐Multitasker ☐ Design Skills

Post-Survey

Answer the following questions by checking a box.

- Q1.1 Engineering is a fun job
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree
- Q2.1 Engineers are important in solving today's real world problems such as quality of health-care and renewable energy
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q3.1 You have to be extremely good in math and science to become an engineer
  ☐Strongly Agree ☐Agree ☐Disagree ☐Strongly Disagree

- Q4.1 What qualities are most important in engineers? (Pick 3)

  ☐Teamwork ☐Strong in Mathematics ☐ Communication

☐Individual problem solver ☐ Leadership ☐Time Management

☐Creativity ☐Strong in Science ☐ Working at a computer all day

☐Strong Writing ☐High IQ ☐Multitasker ☐ Design Skills

- Q5.1 After viewing this video, I am interested in finding out more about a career in engineering (all fields, not just the one in the video you watched).
  ☐Yes ☐No ☐ Unchanged

What aspect of the video influenced your choice?

Short Answer Questions

- Q6.1 Which images presented in the video did you find most interesting and/or inspiring?
- Q7.1 Which images presented in the video did you not find interesting and/or inspiring?
- Q8.1 What were your thoughts on the professionals? Were they informative?
- Q9.1 Are your thoughts about engineering different after viewing the video? In what ways?
- Q10.1 What was the message of this video? Were there multiple messages?
- Q11.1 Did you find the video informative and useful? What information did you think was missing from the video?

Figure 3.3: Pre and Post Video Viewing Surveys Administered to High School and Middle School Students for Electrical and Mechanical Engineering Videos

These new surveys were then answered by 56 students who saw the electrical engineering video and 60 students who saw the mechanical engineering video. All these students were 7th or 8th graders and all were part of a technology and engineering course at at the middle school attended. We were not concerned with having a sample population that showed bias towards engineering because everyone has to take this course at that particular middle school. The course was a supplement subject for students and did not mean that all students were on a path for a STEM career.

The purpose of assessing our video's success using the two versions of the pre and post viewing surveys was to provide the best video possible to inform middle and high school students of what engineers do. We wanted to send a message that engineers do more than just mathematical calculations; they are creative and innovative and they help the world progress. The feedback from the students helped us improve our videos so that they were engaging and informative. Our main goal with making these videos was to make engineering appealing to the students and spark their interest.

3.3 Interviews with Professionals

As described in our literature review, an important way of encouraging students to pursue engineering, especially young girls and minority students, is by providing "visible role models" (Becker 2010). When students are exposed to relatable "visual role models" who succeed at things

that they would like to do in the future, their self-efficacy beliefs about that particular field or specific subjects can improve (Olson and Fagen 2007). In order to present young students with these relatable examples in our videos, we conducted filmed interviews with young engineering professionals who would help students have a visual image of who an engineer is and also have a perspective of what they think of their career and responsibilities in the field.

Based on the research presented in the literature review, we designed a list of interview questions and structured them so that the answers would help support the narrator's statements scripted for the video. These questions are included below.

Interview Questions for Engineering Professionals

Start with introduction of the student/professional, followed by Q&A:

1. What steered you towards a career in engineering?
2. What are your daily responsibilities?
3. What kinds of projects have you worked on?
4. What do you think is the difference between being an engineer vs. a scientist?
5. Who do you think makes a good engineer? What does it take?
6. How important do you feel engineering is to the world/integral in everyday life?
7. How do you tackle new challenges?
8. Is the engineering career you chose anything like what you expected?
9. What are your hobbies? What do you do for fun?

The questions consisted of knowing how the interviewee was interested in engineering, what their daily responsibilities are, the projects they were or are involved in, their opinion on what the difference between an engineer and a scientist is, why they think engineering is important to the world, and how they overcame challenges when it comes to solving problems. We decided on these questions to have a variety of paths to write a script; depending on the responses we can make an informative script and convey the responses to support our statements.

By having the interviewee describe their daily responsibilities, the projects they have worked on and what they think the difference between a scientist and engineer is, we could dispel some of the common misconceptions that students hold about engineering and provide more information about the career itself and the varied opportunities that exist in the field. By having the interviewee discuss how important they think engineers are to the world, we could show in our videos that engineers play a vital role in society and the wellbeing of people which has been shown to increase students' interest in engineering, especially young girls (Klotz et. al 2014; Ing et. al 2014). In addition, it was our hope to be able to demonstrate to students that anyone can become an engineer by having the young professionals discuss what they think makes a good engineer and what it takes. It was our intention through this question to show that a variety of skills are needed in order to succeed as a young engineer that cannot be taught in school. The complete list of questions is included under Appendix E.

Our goal was to contact at least two professionals from the following engineering fields: mechanical engineering, chemical engineering, and electrical and computer engineering. Using their answers not only helped emphasize the points discussed above and in the literature review but it also helped support the themes and messages that our videos were expressing. We also wanted to include interesting projects that the interviewees have worked on to give the students a better perception of what type of work can be done in that engineering field. This would also allow students to see how

topics they will learn in school will be applied in the workplace and how many other skills that are not learned in school are also necessary to thrive as a young engineer.

It was also our intention to interview a diverse group of professionals if possible so that our videos could appeal to a broader group of students. This would subconsciously implant in young students' minds that anyone can become an engineer, no matter their ethnic or gender background. This also provided a much needed "visual role model" for students within the engineering field that may spark their interest in the career.

Professionals were mainly contacted through email and phone. Their contact information was provided by the Students Activities Office at WPI while they were also reached through other contacts such as friends, professors and family members. The interview format was simple and straight-forward with the interviewee sitting in front of the camera with the person conducting the interview sitting in front of them just out of view of the camera. The interviews were casual and conversational in style in order to create a friendly and laid back atmosphere that would be more appealing and approachable to young middle school and high school students.

The locations for recorded interviews varied but they were mostly carried out in simple conference rooms or classrooms in Goddard Hall or Atwater Kent Laboratories. It was our intention to match location with profession of the interviewee to the best of our abilities. For example, interviews with electrical engineers were conducted in electrical engineering laboratories with equipment such as oscilloscopes in the view of the camera. Before each interview, oral consent to release name and workplace was received from every interviewee. When interviewees were contacted, they were also emailed the interview questions to determine if there were any they did not want to answer or needed clarification. In addition, after interviews were completed, participants were given an opportunity to review their answers and omit any or all if they chose to.

Before it was possible to interview professionals on camera, it was again necessary to obtain permission from WPI's IRB. Based on the nature of our project, a formal review from the IRB was not required and a simple Exemption request was submitted. All material necessary for interviews with human subjects on camera were submitted to the IRB and reviewed. Due to the minimal risk involved in this project, the Exemption request was granted and we were free to conduct interviews with young professionals.

3.4 Video Making Process

The videos were created using iMovie and Movavi video editing software, due to their simplicity and ease of learning while still offering powerful video editing tools. None of the members in the group had significant video editing experience, thus avoiding more difficult softwares made this processes easier and less time consuming. The individual scripts for chemical engineering were drafted by each editing team to reflect the overall message developed using the background research and the checklist in Appendix B. For example, we were sure to leave out technical terms that could scare away students, and also insert catch phrases, such as "engineers make a world of difference" as talked about in the *Changing the Conversation* report by the NAE (NAE 2008). Scripts were also written around the multiple interview segments that were included in the videos. If it was determined that a segment of interview had content we really wanted but did not fit with our original script, the script was re-drafted and recorded to retain clarity. Other aspects such as the time limit researched for educational videos was kept in mind when making these videos. The scripting and storyboarding process varied slightly based on editing team but it mostly consisted of developing the main messages we wanted to convey in the video and making sure that the content flow, images and interviews supported these messages.

The narrator recorded these scripts using a professional microphone borrowed from the Academic Technology Center (ATC). As for interviews, equipment was also borrowed from the ATC which included: Bluetooth microphone, Sony HD camera, charger, and camera tripod. The interviews were recorded in a small conference room in Goddard Hall and in Lab 317 in Atwater Kent Laboratories. Interviewees were asked not to stare at the camera to avoid awkwardness in the final videos, as it can be uncomfortable for the viewer to have someone looking straight at them. They were encouraged to have it feel like a conversation with the interviewer. Later, while editing, we made an effort to take out any instances of awkward pauses or glances at the camera. If any awkward moments were essential due to their content, we would put relevant images over them so that a smooth and satisfying flow would be continued.

Images were added to follow the narration and used interview segments which were most pertinent to our message and that fit best with the script. Background music was also added to add to the motivational atmosphere of the videos. All images used for the videos were obtained from online copyright free content collections and every measure was taken to avoid copyright infringement. For example, when using google, an additional search setting was used so that only images labeled for reuse were shown. Copyright music was obtained from the website: Free Music Archive.

After feedback was gathered on the chemical engineering videos, the group once again divided into two editing teams. One team scripted and edited a video about electrical engineering while the other team scripted and edited a video about mechanical engineering. When creating these two videos, the basis for the scripts not only consisted on the checklist created using background research and the different interview segments that were included, but they were also based on the feedback received on the videos about chemical engineering. For example, if the majority of surveyed students thought the video was too long or that some information presented in the videos was confusing, then we made sure that the scripts and edits to these two videos addressed these points. That way the gathered feedback was used to improve the quality of the next two videos.

After the videos on electrical and mechanical engineering were scripted, copyright free images and background music were added using the iMovie and Movavi editing softwares that best matched the script and the initial messages that we wanted the videos to convey. The completed and edited videos were then shown to students once again. Therefore, for each video produced in this project, student feedback was gathered using the several pre and post viewing survey versions made throughout testing in order to assess their effectiveness. The final scripts for each video are included under Appendix B.

4.0 Results and Discussion

4.1 Introduction

Here we present the results gathered for the two versions of the chemical engineering videos using the first version of the pre and post-viewing surveys. These two surveys are included under Appendix B and the purpose of the pre-survey was to get an idea on the perception that students held about engineers and to see if they showed interest in the career. The purpose of the post-survey was to see whether student opinions had changed after being exposed to the video and to gain feedback on the video content and stylistic elements. The results gathered for the new version of the pre and post-viewing surveys for the electrical and mechanical engineering videos are also presented. The purpose of these redesigned surveys was to better address why students' opinions on

engineering might or might not change and what aspects of the videos led to the student's decisions. These surveys are included under Appendix C. The results observed for each video are discussed in this section so we could later make conclusions on what they tell us about each specific video and its effectiveness. The final section contains tables summarizing the overall results. Appendix F contains the raw data for the multiple choice questions of pre and post surveys for all videos.

4.2 Video Content and Message - Chemical Engineering Videos

The content of versions 1 and 2 of the chemical engineering videos was evaluated using the message checklist developed using background research. This checklist is shown below:

Video Message Checklist

1. Show students what engineers actually do.
2. Dispel perception that engineering requires extreme intelligence
3. Demonstrate how many other skills are required for engineering such as creativity, teamwork, communication, time management, etc.
4. Show that engineers are important in solving today's real problems such as quality of health and renewable energy.
5. Show that engineers are not boring but they are in fact enthusiastic and passionate about their work.
6. Present "visual" role-models of engineers.
7. Produce videos that are shorted than six minutes.

The script for version 1 is included in Appendix B-1 and includes segments dedicated to showing what chemical engineers do (message 1) such as "they work to develop materials such as plastics for multiple applications like injection pens for type 1 diabetics" and "from food and fuel to plastics, chemical engineers design the process which go to creating their products." Version 2 (Appendix B-2) also includes information such as "chemical engineers combine knowledge of the physical sciences with some math and economics to produce, transform, and properly use chemicals, materials and energy" to explain what these engineers do. In order to clarify the role of engineers even further images of process design were included in version 2. Version 1 also shows an image used to distinguish science form engineering. Both these images are shown in Figure 4.A.

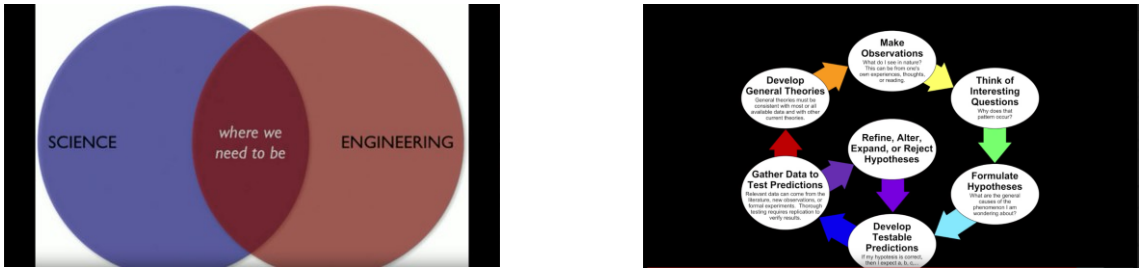

Figure 4.A: Screenshots of version 1 and 2 videos respectively showing images of process design and the difference between a scientist and an engineer.

Version 1 also contains information such as "it may seem that it takes a genius to make the visions of chemical engineers possible, however the important thing to realize is that their skills are learned over years of experience," to dispel the misconception that the profession requires extreme intelligence (message 2). With the same purpose, version 2 tells students that "anyone who puts in

the effort" can become a chemical engineer. Both versions also include interview clips in which professionals list the skills they think are required for engineers to succeed in order to convey the third message on the list (message 3). For example, in both version 1 and 2, an interviewed professional mentions that important skills for engineers include "trusting your own judgment, teamwork, and not being afraid of starting over and trying something new." The interviews were also included to present "visual" role models and to show that engineers are enthusiastic and passionate about their work (messages 5 and 6). This is also achieved through including other images of young engineers at work. Figure 4.B shows several screenshots of the video to demonstrate how they presented the image of an engineer.

Figure 4.B: Screenshots of the video demonstrating the various ways that visual role models were presented.

Finally, version 1 shows applications of chemical engineering such as pharmaceutical drugs and medical devices to convey the message that engineers are crucial for the wellbeing of society (message 4). In the same manner, version 2 tells students that "chemical engineers continue to make a world of difference in green energy, food, safety, medicine, and so much more." Figure 4.C below shows several screenshots of the video demonstrating different images used to help convey message 4 on the list.

Figure 4.C: Screenshots of both version 1 and version 2 demonstrating several images used to convey message 4.

4.3 Pre and Post-Survey Results for Chemical Engineering Videos

In the first round of testing, the two versions of the chemical engineering video were presented to high school students ranging from grades 9 to 12. The video was shown to a total of 193 students from several different classes including two honors chemistry classes, three manufacturing classes, one environmental science class and the school band. The variety of classes was chosen with the end goal of gathering a sample population whose interests were varied and not necessarily a group of students that showed some initial interest in STEM courses or careers. For each class, only one of the two videos was shown and the groups that watched each were chosen at random. In order to consider each video a success, we searched for a positive change in opinion between the pre and post viewing surveys. For example, a message we wanted to convey in both videos is that you do not have to be a genius to become an engineer. It was our hope to see whether there would be a decrease in students who agree with the statement that "You have to be extremely good in math and science to become an engineer" after watching either version of the video. We also seeked for a positive change in Q5 ("I am interested in becoming an engineer"). The version of this video with the most positive response was then presented to 49 7th graders participating in the STEM Saturdays workshop hosted by WPI.

4.3.1 Chemical Engineering Videos - Pre-viewing Survey General Results

All 193 students who participated completed the pre-viewing surveys. Of the students who watched versions 1 and 2 of the video, 58% answered with "Agree" to the statement "Engineering is a fun job" (Q1). 55% of the students answered with "Strongly Agree" to the statement "Engineers are important in solving today's real world problems such as quality of healthcare and renewable energy" (Q2). 60% of students also answered with "Strongly Agree" to the statement "Engineers are problem solvers" (Q3). 53% of students answered with "Agree" to the statement "You have to be extremely good in math and science to become an engineer" (Q4). Finally, 38% of students answered with "Disagree" to the statement "I am interested in becoming an engineer" (Q5). From

these results, it was gathered that the students who answered the pre-survey had a positive view of engineers since they agreed that they helped people and the world and they also knew that engineering is related to problem solving. However, there was only a mild interest in the career since 42% either agreed or strongly agreed with the statement in Q5. Students mostly think that you to be extremely good in math and science to become an engineer.

4.3.2 Chemical Engineering Video - Version 1 Post-viewing Survey Results

Out of the 193 students, 86 completed the post-viewing survey for version 1 of the chemical engineering videos. Of the 86 students, 85 answered questions 1, 2, 4 and 5 while 86 students answered question three. 58% of students answered with "Agree" to the statement in Q1. 85% percent of students answered with "Strongly Agree" to the statement in Q2. 77% of students also answered with "Strongly Agree" to the statement in Q3. 51% of students answered with "Agree" to the statement in Q4 and finally, 42% of students answered with "Disagree" to the statement in Q5.

When comparing the pre and post-viewing results, a change was not observed before and after the students watched the video. In the pre-viewing survey, it was evident that the majority of students either agreed or strongly agreed with the statement that "Engineering is a fun job" (75%). The same was true after the students were exposed to version 1 of the chemical engineering video since 69% either agreed or strongly agreed with this statement. Approximately equal answer percentages were also observed for Q3 and Q5. Therefore the video did not dissuade students from thinking that engineers are problem solvers (Q3). Before watching the video, 90% either agreed or strongly agreed with the statement "You have to be extremely good in math and science to become an engineer (Q4)." After watching the video, 85% also agreed or strongly agreed with this statement. Therefore, our video was not effective in conveying that you don't have to be a genius to pursue the career.

Although a large change was not observed for Q5, it was still interesting to note that before watching the video, 59% either disagreed or strongly disagreed with the statement "I am interested in becoming an engineer." This increased to 63% after the students watched the video. In order for the videos to be considered successful it was important that this percentage decrease by some degree. Therefore, this video was not successful in interesting students in engineering. Finally, the question with the most change was Q2. In the pre-survey, 55% of students strongly agreed with the statement that "Engineers are important in solving today's real world problems such as quality of life and renewable energy." After watching the video, 85% of the students strongly agreed with this statement. Therefore, this video was successful in delivering the message that the wellbeing of the world depends on engineers. Figure 4.1 shows a comparison of the pre and post results for Q1, Q2, Q3, Q4, and Q5 for version 1 of the chemical engineering video.

Q1. Engineering is a fun job

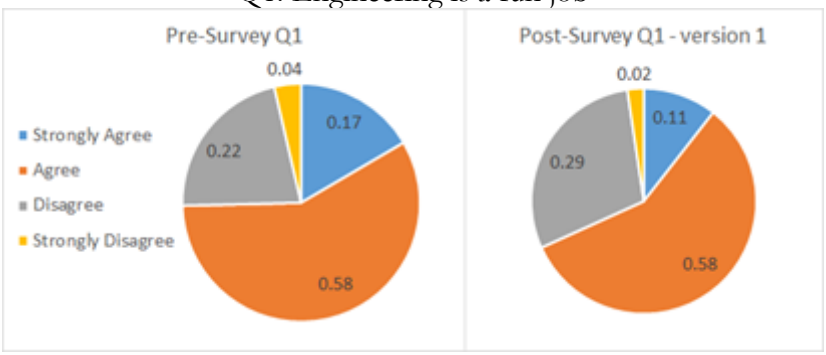

Figure 4.1a: Pie charts showing the results for Q1 for pre and post-surveys for version 1 of chemical engineering video.

Q2. Engineers are important in solving today's real world problems such as quality of health-care and renewable energy

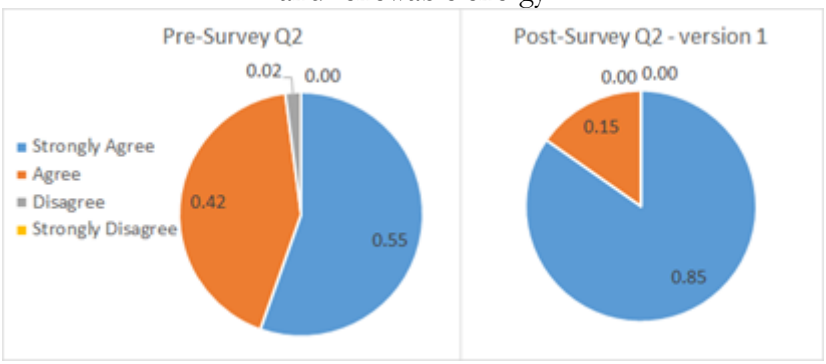

Figure 4.1b: Pie charts showing the results for Q2 for pre and post-surveys for version 1 of chemical engineering video.

Q3. Engineers are problem solvers

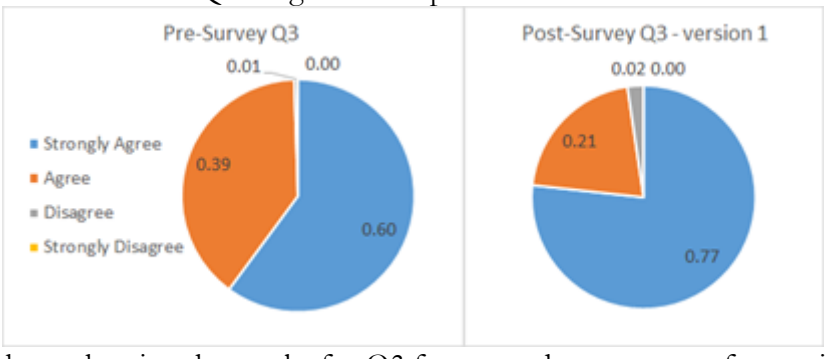

Figure 4.1c: Pie charts showing the results for Q3 for pre and post-surveys for version 1 of chemical engineering video.

Q4. You have to be extremely good in math and science to become an engineer

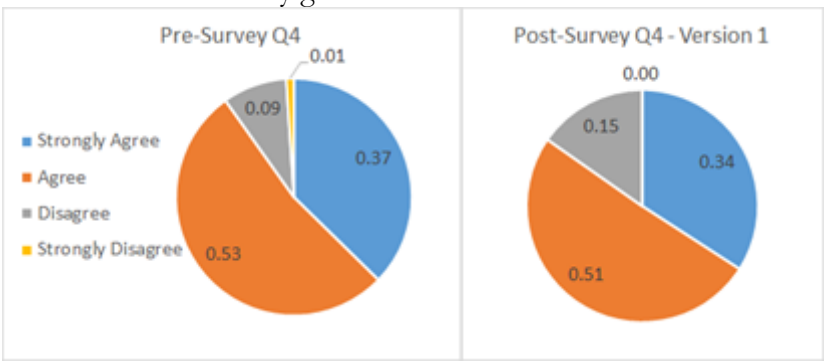

Figure 4.1d: Pie charts showing the results for Q4 for pre and post-surveys for version 1 of chemical engineering video.

Q5. I am interested in becoming an engineer

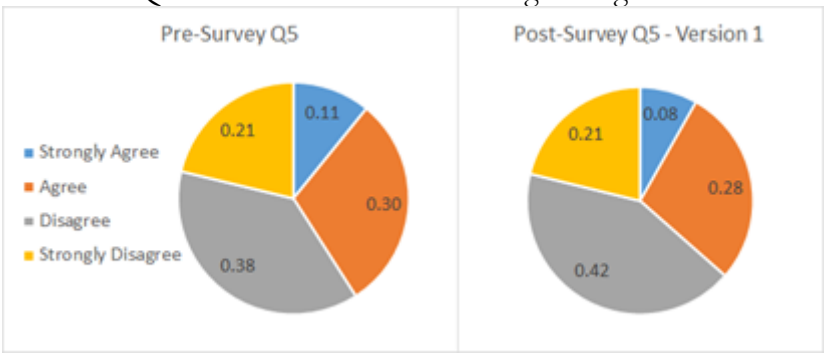

Figure 4.1e: Pie charts showing the results for Q5 for pre and post-surveys for version 1 of chemical engineering video.

For Q6 of the post-viewing survey 86% thought the video was educational while only 37% thought that the video was engaging or entertaining. 18% said the video was boring, 8% that it was too short and 5% that it was too long. Although a majority of the students found the content educational, only about two in five felt engaged while one out of five felt bored. This indicated that the strategy and elements used in this video were not effective in creating the most engaging video possible. On the other hand, the majority of students thought the length of the video was acceptable since only 13% thought it was either too long or too short. Thus the original length of under 6 minutes said to be effective in the literature review was also effective in this case (the length of this particular video was 4 minutes and 25 seconds).

For the short answer question "Which images did you find most interesting and/or inspiring?" (Q7), students mostly found images of chemical engineering products, such as chemicals, cosmetics and medicine, interesting [27 students]. Pictures of engineers working in the field were also considered inspiring, and some answers specifically mentioned images of women engineers [22]. On the other hand, for images that students did not find interesting or inspiring (Q8), the most frequent answers were equations and graphs [16], workplaces that seemed too industrial (Energy, smoke, Petroleum and factories) [13], and students learning [11].

From these results, it was concluded that the right decision was made by including images of engineers working in the field, especially images of female engineers, and pictures relating to health-

care and other chemical engineering products. These results agree with the information in the literature review stating that students find interest in careers that make an impact in the world. This is a message that we wanted to convey using images of pharmaceuticals and diabetic injection pens (Ing at. al 2014). In addition, the students reacted positively to presenting chemical engineering through the products these engineers work to produce.

However, students were disinterested in images that contained mathematical or scientific concepts such as an image that had multiple equations on a blackboard. Although this image was included in the video to go along with the message that people do not have to be mathematically gifted to pursue engineering, students still found the picture uninspiring. From this, it was concluded that this particular message was not successfully conveyed through our video. This was also seen when evaluating the results of Q4 in the pre and post-viewing surveys.

The majority of students did not find any of the content in the video confusing. However, common answers to Q10 included descriptions of chemicals, graphs, equations and math [12], the interviewees [10], and what a chemical engineer does [3]. As expected from the results seen in Q8, 12 students found any content in the video having to do with math and science to be confusing. Also it was to be expected that students find the interviewees confusing since the professionals tended to be very detailed and technical when explaining their daily work. Although we tried to avoid this by asking the professionals to explain their work as if they were speaking to a middle school student, it was still hard to pick apart pieces of information that kids would completely comprehend.

Three students also said that they found the video's explanation of what a chemical engineer does to be confusing. But an overall confusion on what a chemical engineer does was seen in responses to Q11 and Q12. For Q11 ("Did you find the video informative and useful? What information did you think was missing from the video? "), 11 students mentioned that the video needed more information on engineering, other projects that chemical engineers work on, and what steps could be taken to become an engineer. In addition, for Q12 ("What do you think a Chemical engineer does?") the most frequent response was problem solvers that help the world [32]. Although this was a message that we wanted to convey through the video, their answers were not specific as to what a chemical engineer does. Therefore, it was concluded that the video was not successful in conveying this information.

In addition, for Q11, the majority of students found the video to be informative [25]. A total of 9 students also found the video to be boring which is in line with the results observed for Q6. Finally for Q10 ("What were your thoughts on the professionals? Were they informative?"), the majority of students thought the professionals were informative [29]. However, the second most frequent answer was that they were boring shy or unenthused [11]. Therefore, including the interview segments with professionals in this case was not successful in showing students that engineers are enthusiastic and passionate about their work.

From the results seen in Q1 through Q5, there was no significant change in student's overall opinion about engineering from before to after watching the video. However, the data gathered from the post survey was not enough to help us explain why there was no change. Therefore, changes to the survey were made for the testing of the mechanical and electrical engineering videos. From these results we can clearly conclude that version 1 of the video was not very effective in encouraging students to think about engineering as a possible career but the question this data cannot answer is why. Yet, the data gathered still allowed us to make some conclusions about stylistic elements. For example, it was found that keeping the video at a length less than six minutes was successful in keeping students engaged. It was also concluded that the majority of students found the video informational but boring. We could also conclude on which messages were successfully conveyed by the video.

4.3.3 Chemical Engineering Video - Version 2 Post-viewing Survey Results

100 students watched version 2 of the chemical engineering video. 99 students answered Q1, 2 and 3, while 97 answered Q4 and all 100 answered Q5. 59% of students answered with "Agree" to the statement in Q1 and 68% answered with "Strongly Agree" to the statement in Q2. 68% of students also answered with "Strongly Agree" to the statement in question 3. 60% of students answered with "Agree" to the statement in Q4 and finally, 38% answered with "Disagree" to the statement in Q5.

Similar to ChE video 1, no significant change was observed before and after students were exposed to version 2 of the video. 58% of students agreed with the statement that "Engineering is a fun job" in the pre-survey while 58% also agreed with this statement after viewing the video. Similar percentages were also observed in the pre and post survey answers for Q2, 3, 4 and 5. Therefore, after watching the video, the majority of students still thought that engineers are important for the wellbeing of society and that they are problem solvers (Q2 and Q3). In addition, students were impacted negatively for Q4. In the pre-survey, 53% of students agreed with the statement "You have to be extremely good in math and science to become an engineer." After watching the video, the number of students who agreed with this statement increased to 60%. Therefore this video was not effective in conveying the message that you do not have to be gifted in math and science to become an engineer. And since no change was observed for Q5, this video was not effective in interesting kids in engineering. Figure 4.2 shows the results obtained for Q1-Q5 in the pre and post-surveys.

Q1. Engineering is a fun job

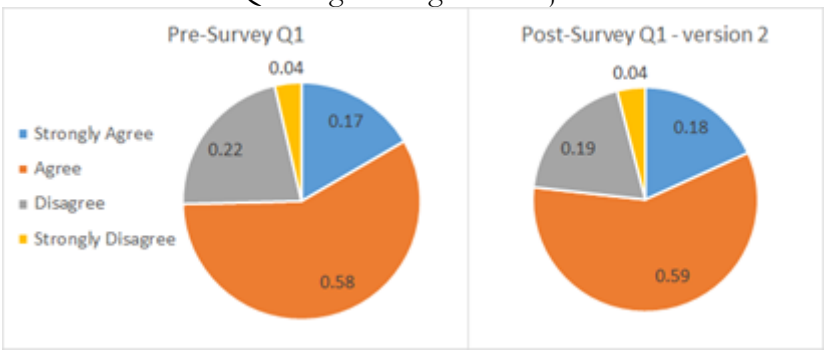

Figure 4.2a: Pie charts showing the results for Q1 for pre and post-surveys for version 2 of chemical engineering video.

Q2. Engineers are important in solving today's real world problems such as quality of health-care and renewable energy

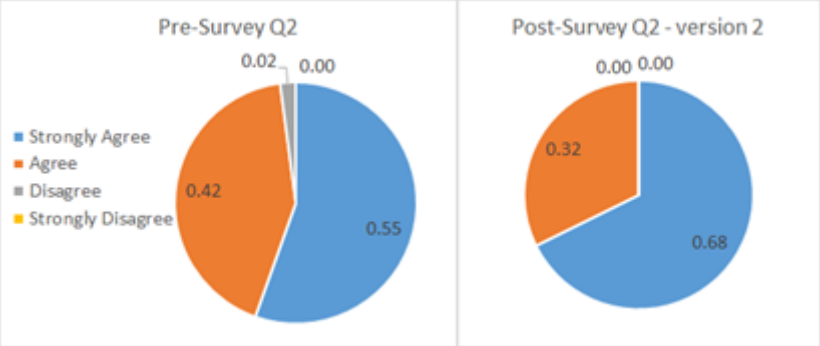

Figure 4.2b: Pie charts showing the results for Q2 for pre and post-surveys for version 2 of chemical engineering video.

Q3. Engineers are problem solvers

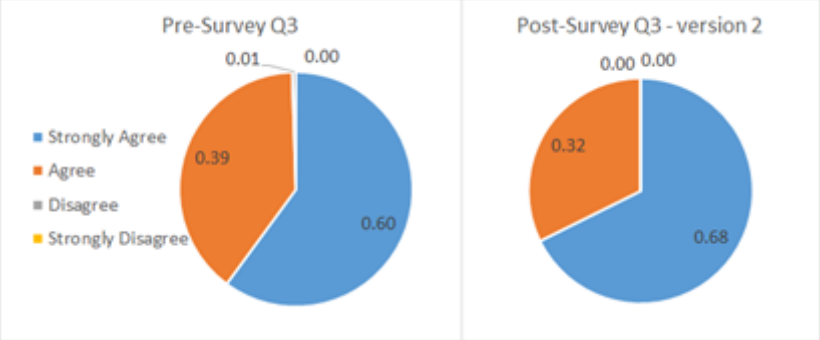

Figure 4.2c: Pie charts showing the results for Q3 for pre and post-surveys for version 2 of chemical engineering video.

Q4. You have to be extremely good in math and science to become an engineer

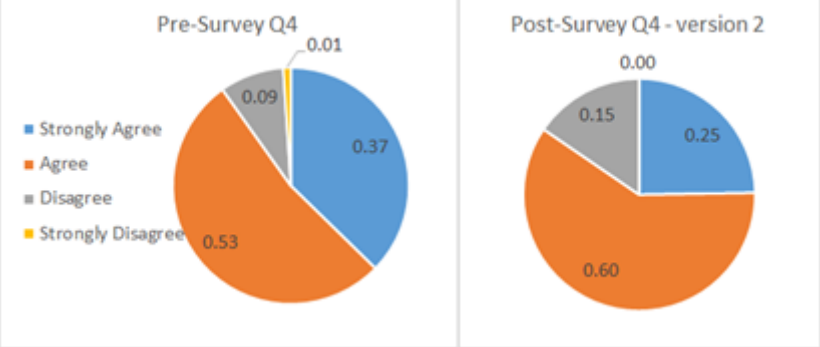

Figure 4.2d: Pie charts showing the results for Q4 for pre and post-surveys for version 2 of chemical engineering video.

Q5. I am interested in becoming an engineer

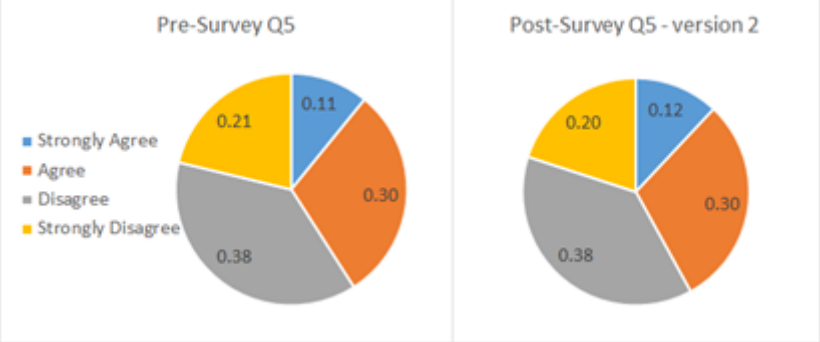

Figure 4.2e: Pie charts showing the results for Q5 for pre and post-surveys for version 2 of chemical engineering video.

For Q6, 86% of students thought that the video was educational while 42% believed it was engaging and entertaining and 13% thought it was boring. Therefore, this video had a mild response when it comes to entertaining qualities. As for length, the majority of students responded positively since only 5% thought it was too long and only 9% thought it was too short. This further confirms that the length of under 6 minutes was appropriate. This particular video was four 4 minutes and 56 seconds long.

For Q7, students mostly mentioned images such as engineers at work [17], students preparing to become engineers [7], chemicals [6], interview clips [6], prosthetic legs [4], and solar panels [4]. Therefore, students reacted positively to seeing engineers at work as well as interviews with professionals. In addition, they approved of chemical engineering product pictures such as the prosthetic legs and solar panels. This shows that by utilizing the "medical field" approach in both videos, i.e. presenting engineering to students through the impact they have in the world, the video is more effective in sparking student interest. Interestingly, some students mentioned that images of equations [5] were interesting or inspiring. The sample populations to which both videos were shown contained students from manufacturing classes and honors science classes, therefore there were surveyed students who already had some inclination towards STEM fields.

Images that students did not find interesting or inspiring included the time lapse of the city [9], people studying [5], chemicals [5], and interview clips [3]. The introduction of this video contained a time lapse of a city as the narrator discussed how engineers are modern unsung heroes but most students reacted negatively to this segment. As for images of chemicals, there was an even reaction since 5 students thought these images were uninteresting while 6 found them inspiring. Also, some students reacted negatively to images of people studying, whereas more students reacted positively [7].

The majority of students did not find any part of the video confusing [48]. However, the things that students did find confusing included the interviewees [4], what a chemical engineer is [2], and the prosthetics [2]. Again, it is not surprising that students found the interviewees confusing since they spoke with technical terms that middle and high school students have not been exposed to. We concluded that for future videos, it would be preferable to exclude segments in which the interviewees discuss processes or projects in very technical ways. For interviews that were conducted after this round of testing, the professionals were asked to describe their worked in simple terms that kids would understand. It was also gathered that students found images of prosthetics to be confusing because the connection between this particular product and chemical engineers was not made clear enough.

Even though two students said the information on who a chemical engineer was confusing, this response was indirectly gathered from Q12. 36 students answered with things such as chemical engineers are innovative, they solve problems, and they help the world. These were all true and in line with messages that this video wanted to get across but they were still not indicative of what a chemical engineer exactly does. Another 20 students gave vague answers to Q12 and four students were not sure at all. We determined that version 2 of the video was not successful in explaining to students who a chemical engineers are and what they do.

This was also seen in the question that asked students to give their overall thoughts on the video (Q11). Six students mentioned that it was lacking information on engineering while another five students wanted more examples of projects that chemical engineers work on. But the majority of students [40] found it to be informative. When asked to give their opinions on the professionals, most students said they were informative [52] while five students mentioned they wanted to know more about the projects they worked on. We concluded that adding the interview clips in our videos helped spark an interest of some students. However, for these particular professionals, another five students found them to be monotone, boring, quiet or shy.

From the results seen in Q1 through Q5, no change in student's opinion about engineering from before to after watching the video was seen. This was also observed for version 1. However, the data gathered from the post survey was not enough to help us explain why there was no change after students saw either of the chemical engineering videos. Again, changes to the survey were made for the testing of the mechanical and electrical engineering videos. From these results we can clearly conclude that version 2 was not very effective in encouraging students to think about engineering as a possible career but we do not know why. Yet, the data gathered still allowed us to make some conclusions about stylistic elements. For example, it was found that keeping the video at a length less than six minutes was successful in keeping students engaged in both versions. It was also concluded that the majority of students found both videos informational but boring.

4.3.4 Chemical Engineering Video - Comparison Between Version 1 and 2

When compared to version 1, version 2 of the chemical engineering video had a better response when it comes to entertaining and engaging qualities. However, the difference was not great. Slightly less students found this video to be boring compared to version 1 since only 37% thought version 1 was engaging compared to 42% for version 2 (shown in Figure 4.3). The responses for Q6 for both version 1 and 2 of the video are compared in Figure 4.3 below. Although a large difference is not clearly observed, one of the reasons why version 2 was determined to be better was because slightly more students thought it was engaging.

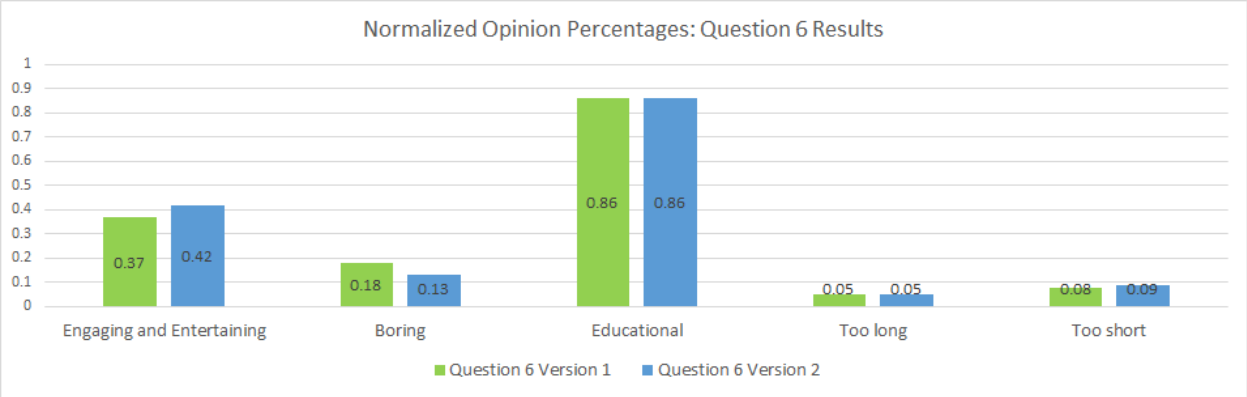

Figure 4.3: Comparison of the results for Question 6 of the Post-Survey of version 1 and 2 of the chemical engineering video.

In addition, after version 2 was shown, less students disagreed with the statement "I am interested in becoming an engineer" when compared to version 1. Figure 4.4 below shows a comparison between versions 1 and 2 on the percent change for students disagreeing with this statement before and after viewing each version. It can be seen in the figure that after watching version 2, less students disagree with this statement. Therefore we concluded that this video was slightly more successful in interesting students

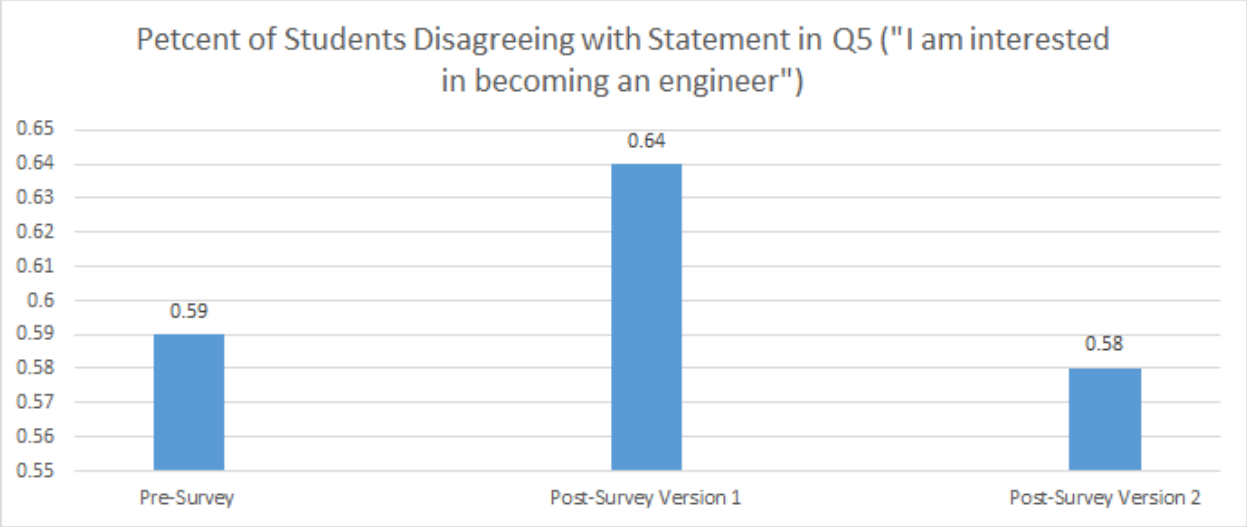

Figure 4.4: Percentage of students who disagreed with the statement in question 5 after watching version 1 and 2 of the chemical engineering video.

After closely reviewing both videos once more, it was also determined that version 1 contained more images that showed complex equations and scientific concepts and it also had an large interview segment in which the interviewee explained her daily work in complex terms. The video also contained multiple images of factories and smokestacks that were too industrial which most students reacted negatively to. In contrast, the interview segments used in version 2 were shorter and they did not delve deeply into the details of the professional's work. Version 2 also contained less images that were too industrial and it had no images whatsoever of equations. Therefore this video was chosen for testing in STEM Saturdays.

4.3.5 Chemical Engineering Video - STEM Saturdays Version 2 Pre and Post-Viewing Survey Results

Version 2 was shown to 49 7th grade students who participated in STEM Saturdays hosted by WPI. In the pre-survey, 55% answered with "Agree" to the statement in Q1 while 65% answered with "Strongly Agree" to the statement in Q2. 69% also answered with "Strongly Agree" to the statement in Q3 while 47% answered with "Agree" to the statement in Q4. Finally, 47% answered with "Strongly Agree" to the statement in Q5. From these results we gathered that students mostly showed an inclination towards engineering since the majority of students either agreed or strongly agreed with statements in Q1 and Q2. A majority of students also agreed or strongly agreed with the statement "I am interested in becoming an engineer." This was expected since this particular sample population was participating in an outreach event centered on STEM activities.

In the post-survey, 53% answered with "Strongly Agree" to the statement in Q1 while 73% also answered with "Strongly Agree" to the statement in Q2. 63% also answered with "Strongly Agree" to the statement in Q3 and 37% answered with "Agree" to the statement in Q4. Finally, 45% answered with "Strongly Agree" to the statement in Q5. Therefore, a change from before to after viewing the video was more noticeable with these middle school students than with the previous high school group. One of the questions with the most change was Q2. In the pre-survey, 65% agreed with the statement that "Engineers are important in solving today's real world problems such as quality of healthcare and renewable energy." In the post-survey, this increased to 73%. From this it was concluded that the video was successful in delivering this message to the students.

In addition, Q1 also saw a 10% increase in students that strongly agreed with the statement "Engineering is a fun job." Therefore, this video effectively demonstrated that engineering is not a boring profession as most people think. And since no change was observed for Q3, the video did not dissuade students from thinking that engineers are problem solvers. Although there was some slight decrease in the students that agreed or strongly agreed with the statement in Q4, it was still not enough for us to consider the video as successfully delivering the message that you don't have to be a genius to pursue engineering. Finally, there was a six percent decrease in students who either agreed or strongly agreed with the statement "I am interested in becoming an engineer." Therefore, this video was not successful in interesting students in engineering. Figure 4.5 shows a comparison of the pre and post survey results for Q1-Q5.

Q1. Engineering is a fun job

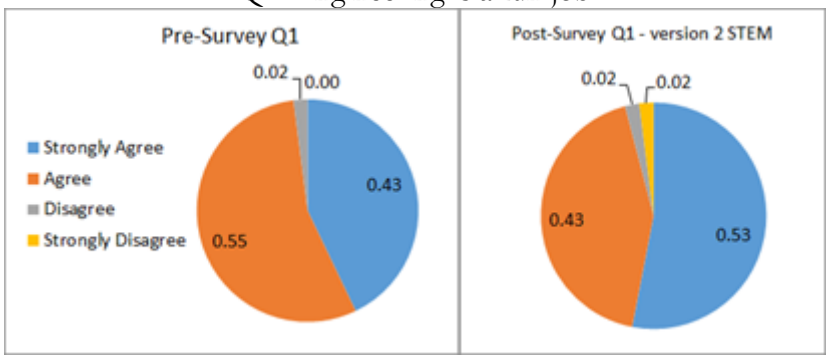

Figure 4.5a: Pie charts showing the results for pre and post-survey Q1 for version 2 of chemical engineering video observed in STEM Saturday.

Q2. Engineers are important in solving today's real world problems such as quality of health-care and renewable energy

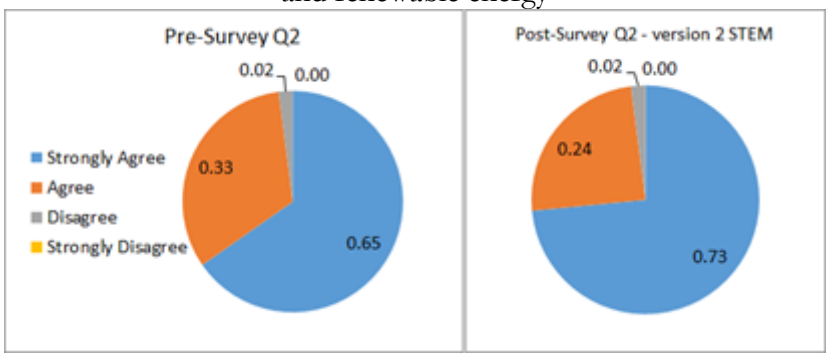

Figure 4.5b: Pie charts showing the results for pre and post-survey Q2 for version 2 of chemical engineering video observed in STEM Saturday.

Q3. Engineers are problem solvers

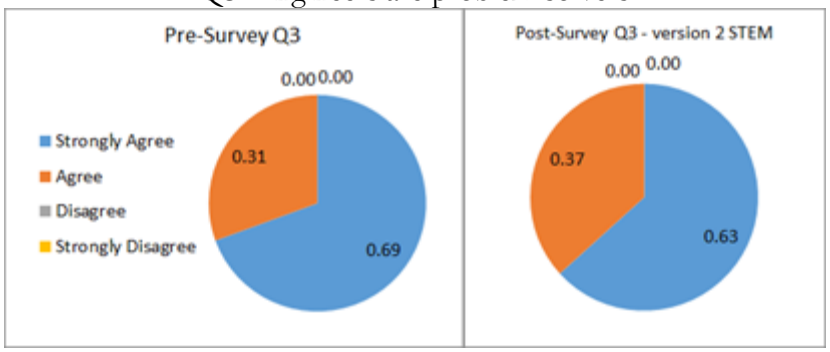

Figure 4.5c: Pie charts showing the results for pre and post-survey Q3 for version 2 of chemical engineering video observed in STEM Saturday.

Q4. You have to be extremely good in math and science to become an engineer

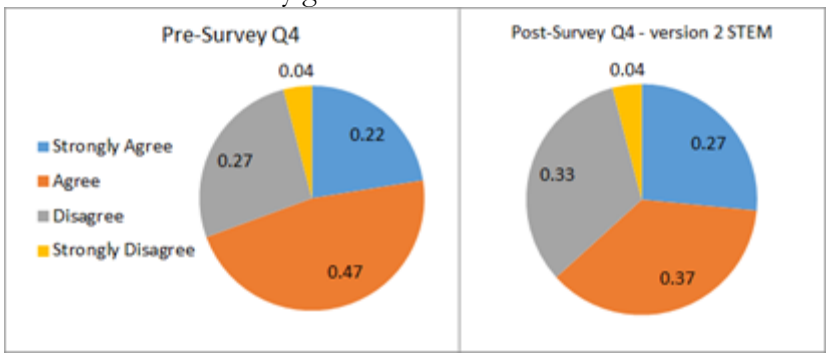

Figure 4.5d: Pie charts showing the results for pre and post-survey Q4 for version 2 of chemical engineering video observed in STEM Saturday.

Q5. I am interested in becoming an engineer

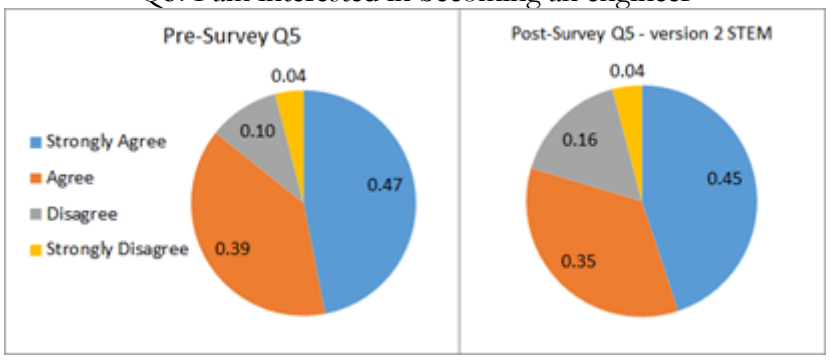

Figure 4.5e: Pie charts showing the results for pre and post-survey Q5 for version 2 of chemical engineering video observed in STEM Saturday.

For Q6, 53% thought that the video was engaging and entertaining while 86% thought it was educational. 24% believed the video was boring, 27% said it was too short and 6% said it was too long. Even though more than half thought the video was engaging, around 12 students still thought it was boring. Although this was a more positive response than seen in the results for the high school students, the fact that 26% thought it was boring still led us to conclude that the video was not engaging. However, the vast majority did think it was educational. In this sample population, the response for video length was less positive than seen for the high school group since around 13 students said the video was too short. But again, these were students that had shown interest in STEM fields and we concluded that they felt the length of under six minutes was not enough to convey all the additional information they wanted to know. But as expected, 94% thought it was not too long. Therefore the chosen length was still considered acceptable.

For Q7, the top three answers were applications of engineering and engineers at work [15], medical related images [12], and products [9]. These results were similar to the ones seen in the ones obtained with the high school group. Thus overall, picking images that showed engineers at work and that showed different products that engineers work on, especially in the medical field, was successful in engaging these students. On the other hand, when asked to describe images that they did not find interesting or inspiring, the top answer was pictures of chemical compounds and math [8]. Students did not find any images with science or math related topics to be inspiring or interesting. From this, we concluded that these pictures should be avoided.

As seen before, answers to Q12 revealed that this video was not very effective in conveying to students what chemical engineers do. The top answers for this question were that engineers are innovative and they help the world by solving problems [24] and that they work with chemicals [16]. While these are true, they are still not indicative of what chemical engineers actually do. From this, it was seen that the video was successful in conveying to students that chemical engineers are important in helping the world and solving problems but it was not successful in providing information as to how they improve society. This was also seen in the response given for Q13, which asked the students to talk about any information they thought was missing. Although 40 students said that the video was informative, six still stated that the video was lacking information on what engineers do and four wanted to know what they could do in order to become engineers.

As for their thoughts on the interviewed professionals, the most common answer was that they were informative [40]. However three students did think that the professionals were boring and hard to understand. But since the majority of student had no complaints on the professionals, it was

concluded that this group of students had a positive reaction to them and thus including interview segments did not take away from any of the video's positive qualities.

Again, the data gathered using these pre and post-surveys was not detailed enough to help us formulate why little change was observed from before to after viewing the video. However, based on our established criteria, this video was not effective in encouraging young students to think about engineering as a possible career. The data was mostly useful in helping us determine which stylistic elements were effective. For example, the established length of below six minutes was found to be effective with the majority of students in this sample population but it was also concluded that the video was not as entertaining as was hoped since 24% thought it was boring. And from the short answer questions it was found that including images of engineers at work, images of products, and images related to the medical field was effective in keeping the students mostly engaged. But it was found that the video was not effective in showing students what chemical engineers actually do.

4.4 Video Content and Message - Mechanical and Electrical Engineering

Based on results obtained for versions 1 and 2 of the chemical engineering videos, two lists were created: one that contained elements we should eliminate based on student response and one with elements we should keep. These lists were used as reference when scripting and editing the electrical and mechanical engineering videos. Both lists are shown below.

Table 4.1: Video elements that could be kept and video elements that could be eliminated based on student response.

Element we can keep	Elements to eliminate or do differently

• Positive Images
  ○ images of engineers at work
  ○ women actively working
  ○ images of products engineers work to produce
  ○ images of medical related products
• Positive Information
  ○ applications of engineering
  ○ video was concise and straightforward
• Other Positive Elements
  ○ Length of under six minutes
	• Negative Images
	  ○ images with mathematical and scientific concepts
	  ○ confused students
	  ○ images that are too industrial
	  ○ images that were random and not connected to the script
	• Improve Interview Segments
	  ○ Professionals were awkward or unenthused
	• Information to add
	  ○ be more specific about what engineers do
	  ○ give more examples of what engineers work on
	  ○ Include information on how students can prepare to become engineers

In addition, the videos were evaluated using the video message checklist and emphasis was put on the messages that were not successfully conveyed by the ChE videos. The first one being what engineers actually do. When editing the electrical engineering video a greater effort was put

into showing what an electrical engineer does. The script shown in Appendix B-3 dedicates a section to briefly describing the role of electrical engineers and the different applications in the field. They "design, develop, test and supervise the manufacturing of electrical equipment. They use concepts of electricity to solve problems related to energy, power, information processing and communication." The same emphasis was made in the mechanical engineering video. Its script shown in Appendix B-4 has a large section on what mechanical engineering is and it states that "Mechanical engineering is the field in engineering with its roots in the physical properties of systems: how things move and why." Multiple examples and applications are mentioned and explained in both videos. For example, how electrical engineers work either in the energy sector or making products such as phones and computers. Mechanical engineers work designing cars and airplanes and other machines such as drones.

Since students has reacted positively to images of products that engineers work to design as shown in Table 4.1, a greater emphasis was made in these two videos to show multiple examples of what electrical and mechanical engineers work to produce. Figure 4.D below shows examples of the exciting products, machines and structures that were included in both videos in order to interest students.

Figure 4.D: Screenshots of the electrical and mechanical engineering videos showing examples of the many products presented in the videos that these engineers work to design and produce.

These new videos also needed to better emphasize the message that engineering does not require extreme intelligence and that other skills are needed that are not taught in school. Therefore, no images containing math and science were used in the electrical engineering video and an interview segment in which a professional describes how math knowledge will not define your career was included. On the other hand, the mechanical engineering video puts a lot more emphasis on what these engineers actually do and includes a number of images that have mathematical and scientific concepts. However, these were explained in simple terms to avoid confusing students. As mentioned in the list above, additional information on how students can prepare to become engineers was also added to the electrical engineering video. For example, the script contains the line "Talking to your teachers and school counselors can help you figure out how you can prepare to become an engineer."

These videos also needed to have better "visual" role models. Great care was taken when choosing interview segments for the electrical engineering video and they showed the professional speaking about their work in simple terms and in an enthusiastic manner. To increase entertaining qualities, less time was dedicated to interview segments in this video compared to the chemical engineering videos. The mechanical engineering video did not contain any interview segments at all in order to see if this gathered a more positive response. Like listed in table 4.1, students had also reacted positively to showing engineers at work, especially women. Therefore, more images of engineers working were also included to present visual role models and to demonstrate that engineers are enthusiastic and not boring. Figure 4.E shows screenshots of both videos with several examples of engineers.

Figure 4.E: Screenshots of electrical and mechanical engineering videos demonstrating how engineers were portrayed.

Both videos also dedicate large portions to showing how engineers have an impact in society, especially in the medical field, which students reacted positively to. Figure 4.F shows screenshots of both videos demonstrating the impact that engineers have in the medical field. The total information content of the videos was also kept concise, which students reacted positively to.

Figure 4.F: Screenshots of the electrical and mechanical engineering videos demonstrating examples of the impact that engineers have in the medical field.

4.5 Pre and Post-Survey Results for Mechanical Engineering Video

The mechanical engineering video was presented to 61 students from 7th and 8th grade. It was presented in a technology and engineering course offered by the school, which is taken by all students so we were not concerned with sampling a group that had an initial positive inclination towards engineering. In the improved version of the pre-survey 69% answered with "Agree" to the statement in Q1.1 ("Engineering is a fun job") and 62% also agreed with the statement in Q2.1 ("Engineers are important in solving today's real world problems such as quality of health-care and renewable energy"). 45% also answered with "Agree" to the statement in Q3.1 ("You have to be extremely good in math and science to become an engineer") while 51% answered with "Disagree" to the statement in Q4.1 ("I am interested in becoming an engineer"). Finally, when asked about qualities of engineers (Q5.1), 79% said that teamwork was an important skill or quality for engineers and so was communication (49%), creativity (52%), leadership (27%), strength in math (30%), and design skills (41%). A very small number of students felt that engineers were individual problem solvers, that they are strong in science, that they have strong writing, or that they have a high IQ.

From these results, it was gathered that the students had a positive view of engineers since the majority agreed or strongly agreed with the statements in Q1.1 and Q2.1. However, the majority thought that engineers need to be extremely good in math since 45% agreed with the statement in Q3.1 and 30% thought this was a necessary skill for an engineer. In addition, most students were not interested in becoming engineers since 67% disagreed or strongly disagreed with the statement in Q4.1. When it comes to qualities and skills of engineers, students mostly sad that engineers are creative and work in teams and they need strong communication and design skills. Some students also thought that engineers are leaders and that they need to be strong in mathematics.

In the post-survey results, 60% agreed with the statement in Q1.1 while 61% strongly agreed with the statement in Q2.1 and 53% agreed with the statement in Q3.1. When comparing pre and post-survey results, a large change in opinion was not observed for these three questions. The question that had the most change in results was Q3.1. Before watching the video, 68% agreed with the statement that "You have to be extremely good in math and science to become an engineer," but after watching the video it increased to 75%. The same was seen when students were asked to check

qualities and skills that engineers must have. 30% thought engineers need to be strong in math, which remained constant after watching the video. Therefore this video was not successful in conveying the message that you do not have to be exceptional in math and science to become an engineer. Q2.1 also saw some change since 35% strongly agreed with this statement but after watching the video this increased to 61%. Therefore this video was successful in conveying the message that mechanical engineers help the world. There was also a 9% increase of students who strongly agreed with the statement under Q1.1, thus this video was successful in portraying engineering as a fun job. Figure 4.6 shows a comparison of the pre and post survey results for Q1.1-Q3.1.

Q1.1 Engineering is a fun job

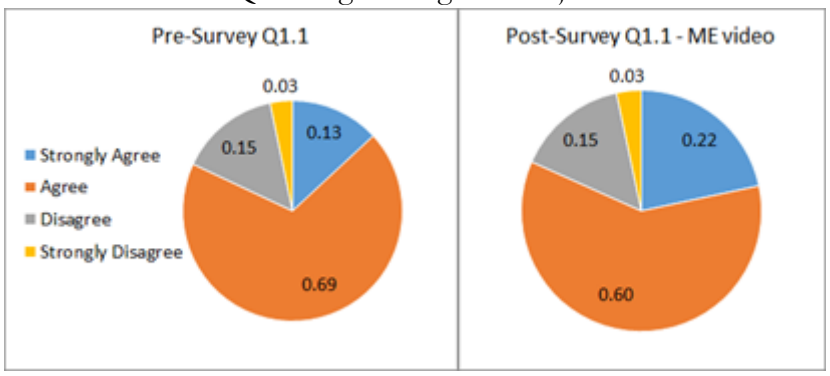

Figure 4.6a: Pie charts showing the results for questions Q1.1 for the pre and post-surveys of mechanical engineering video.

Q2.1 Engineers are important in solving today's real world problems such as quality of health-care and renewable energy

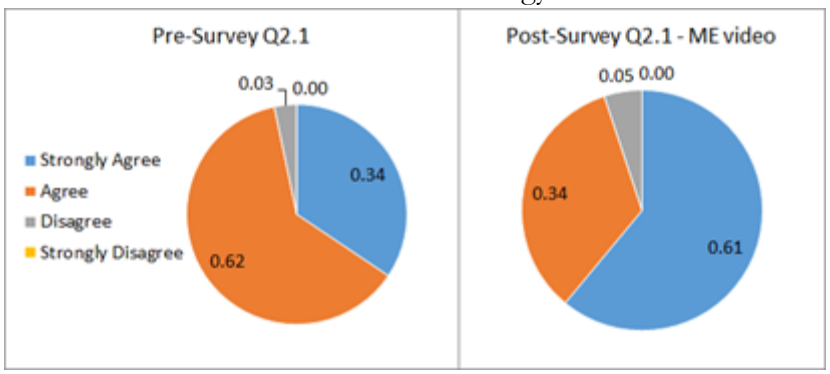

Figure 4.6b: Pie charts showing the results for questions Q2.1 for the pre and post-surveys of mechanical engineering video.

Q3.1 You have to be extremely good in math and science to become an engineer

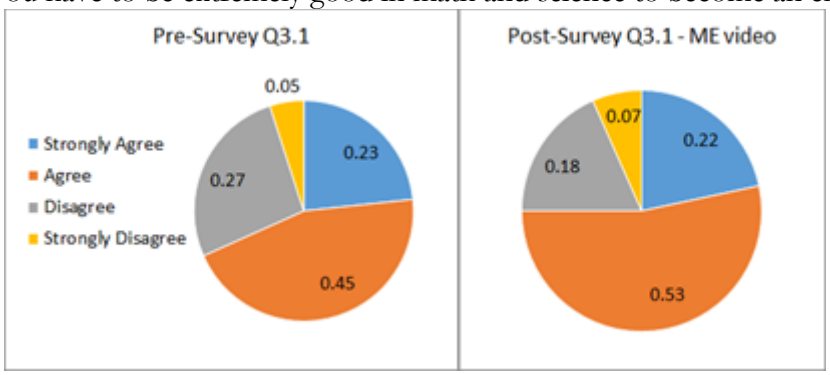

Figure 4.6c: Pie charts showing the results for questions Q3.1 for the pre and post-surveys of mechanical engineering video.

Other interesting trends were also observed for Q5.1 (Q4.1 in post-survey). Before watching the video, 79% said that teamwork was an important skill for engineers but it decreased to 55% after watching the video. In addition, 7% said engineers are individual problem solvers, and this increased to 22% after watching the video. Leadership also decreased from 28% to 18%. The rest of the quality and skills remained constant. We concluded that the reason these particular skills or qualities were less chosen after is because this video had no interviewee clips. In other videos, skills such as teamwork were mostly spoken about by the professionals who were interviewed. However, for this particular one, we wanted to try a different approach by not including any interviewees. In addition, it was gathered that this video leaned heavily on the problem solving aspect of engineering which led students to think that engineers are individual problem solvers. We concluded that for next attempts it would be more effective to show that engineers work in teams to solve problems and not by themselves. When students think engineers have little interaction with people, they are less likely to think of it as a future career.

For Q5.1 of the post-survey ("After viewing this video, I am interested in finding out more about a career in engineering (all fields, not just the one in the video you watched)"), 45% responded with yes, 23% with no, and 32% with unchanged. Therefore, this video was successful in sparking the interest of half of the students surveyed. 19 students said the video had not changed their interest in engineering and around 14 students said the video did not incite their interest at all. With this question we also asked the students to briefly explain their answer in order to understand why the video did or did not interest them in engineering. Students that answered yes mentioned aspects of the video such as how it shows engineers doing creative things, how it makes the job look fun, how the engineers make cool stuff, how it shows medical and military machines such as drones, and how it shows that without engineers, we would not live comfortable lives. On the other hand, students that answered with no mostly mentioned that the video was boring. Therefore, students that found no interest did not give specific elements of the video that led to their answer.

Students found image such as phones [12], cars [9], bridges, houses and structures [7], the golden ratio [7], drones [4], army gear [4], health inventions [2], and climate control technology [2] as being interesting or inspiring (Q6.1). Therefore the students reacted positively to showing mechanical engineering through the products that engineers work on and how they have a big impact in society. Images that students did not find interesting or inspiring (Q7.1) included pictures of math equations and charts [4], pictures of cars being made [3], an image of a girl bungee jumping [2], and what many students referred to as random images. From this we determined that, again, images that revolve around math and science concepts that middle school students have not seen yet

in school should be avoided. In addition, images that show the industrial side of engineering should be avoided as well. Finally, these students reacted negatively to images that they thought were filler and had no connection to the messages of the video.

This video had no clips of interviewed professionals and thus the students were told to leave Q8.1 blank. For Q9.1, which asked students to explain if the video had changed their thoughts on engineering, answers were that they realized that engineering is fun and important [5], that there are many types of engineering [2], and finally, that it is interesting and that they want to know more about it [1]. Two students also mentioned in this question that after watching the video, they were now considering engineering as a possible career.

When asked to describe what they thought the message(s) of the video were (Q10.1), answers included engineers are vital and important in everyday life and they help society with their designs [19], what engineers do in the workplace [3], that there are many types of engineers [3], that students should consider engineering as a possible career [5], and that the profession can fun despite its reputation [1]. Therefore, this video was successful in conveying the message that engineers are important in helping the world and society but the profession can be fun at the same time. The video was also successful in informing students what it is that mechanical engineers do exactly.

Finally, when asked to give their thoughts on the video (Q11.1), students mostly mentioned that the video was interesting [7]. Yet some students wanted more information such as how to become an engineer [1], what the history of engineering is and to explain more of what they do [2], and to talk more about the computer side of engineering [1]. Only four students in all surveyed classes thought that the video was not useful therefore we concluded that the majority of students reacted positively to the video while some wanted to know other information that was not necessarily included in the original messages that we wanted to convey.

4.6 Pre and Post-Survey Results for Electrical Engineering Video

The electrical engineering video was presented to 56 7th and 8th grade students who were part of the technology and engineering course offered at the visited middle school. In the pre-survey, 59% answered with "Agree" to the statement in Q1.1 while 50% answered with "Strongly Agree" to the statement in Q2.1. 46% answered with agree to the statement in Q3.1 while 46% answered with "Disagree" to the statement in Q4.1. For Q5.1, 66% said that teamwork is an important skill or quality for engineers and so is strength in math (46%), communication (50%), creativity (54%), and design skills (41%). Less students thought that engineers were individual problem solvers (13%), or that engineers require leadership skills (18%) or strength in science (14%). Even less students thought that engineers work at a computer all day (2%) or that they have a high IQ (4%). From these results it was gathered that students had a positive view of engineers since the majority of students agreed with the statements in Q1.1 and Q2.1. However, they showed a mild interest in the career since 66% disagreed or strongly disagreed with the statement "I am interested in becoming an engineer."

In addition, students perceived engineers as having skills such as communication and working in teams, having design skills and being strong in math. Although students thought engineers have to be good at math, they did not think that they need high IQs. In the post-survey results, 52% answered with "Agree" to the statement in Q1.1 while 59% answered with "Strongly Agree" to the statement in Q2.1 and 38% answered with "Agree" to the statement in Q3.1. For qualities and skills that engineers possess (Q4.1 in post survey), the majority of students chose teamwork (54%), strength in mathematics (50%), communication (43%), creativity (64%), strength in science (25%), and design skills (45%).

A more noticeable change from before to after viewing the videos was observed for this video. Q3.1 showed a positive change since before watching the video, 66% either agreed or strongly agreed with the statement "You have to be extremely good in math and science to become and engineer," but this declined to 58% after. Therefore, this video was successful in conveying the message that you do not have to be genius to become and engineer. Q2.1 also saw a noticeable change since in the pre-survey, 9% disagreed with the statement in this question and in the post-survey only 2% strongly disagreed with this statement. Therefore we were successful in conveying to students that engineers are crucial in helping the world and improving the wellbeing of people. Finally, 5% more disagreed with the statement in Q1.1, thus this video was not as successful in convincing students that engineering is a fun job. Figure 4.7 shows a comparison of the pre and post survey results for questions Q1.1-Q3.1.

Q1.1 Engineering is a fun job

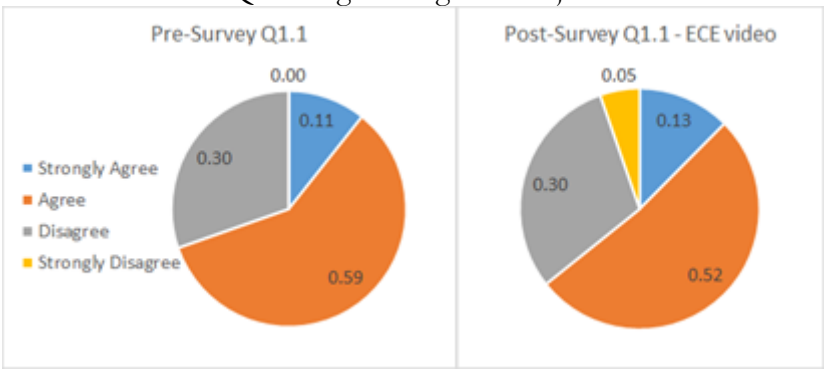

Figure 4.7a: Pie charts showing the results for questions Q1.1 for pre and post-surveys of electrical engineering video.

Q2.1 Engineers are important in solving today's real world problems such as quality of health-care and renewable energy

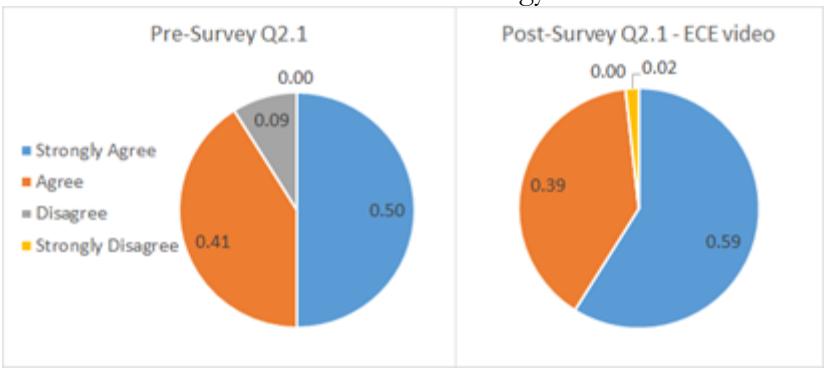

Figure 4.7b: Pie charts showing the results for questions Q2.1 for pre and post-surveys of electrical engineering video.

Q3.1 You have to be extremely good in math and science to become an engineer

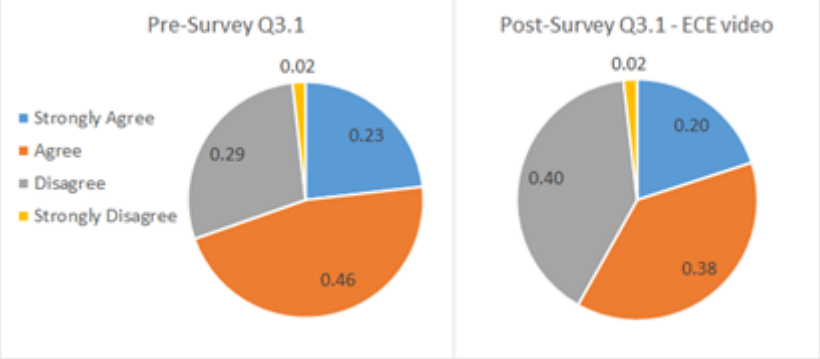

Figure 4.7c: Pie charts showing the results for questions Q3.1 for pre and post-surveys of electrical engineering video.

Finally for Q5.1, 41% said that they were interested in researching more about engineering after watching the video while 32% said no and 27% said their interest was unchanged. Therefore, this video was successful in encouraging 23 students to learn more about engineering after having watched the video which is better than the 18 students who reported no interest. When asked to explain what aspect of the video influenced their choice, students who answered yes mentioned how the video demonstrated that the technology presented exists thanks to engineers and that the impact they make is great [6] and the interviewees [4]. Students also mentioned the impact that engineers have on health [2], that they enjoy engineering [2], how engineering is used to solve problems and incite creativity [1], the computer technology presented [1], and the type of work involved with engineering [1]. From this we gathered that the main reason that the video interested students in engineering is because of technology and modern products shown and how they have an impact on people. In addition, showing actual professionals was the second major reason. But as expected, some students reacted positively to the video because they already had initial interest in the profession.

Students who answered with no or unchanged, mentioned that they had no interest in engineering at all [12], that math is involved [2], or the students already had decided on their future career [2]. Therefore, the most common reason why students found no interest in the profession was an external factor that had nothing to do with aspects of the video. The students either had already decided on other careers in STEM such as marine biology [1], or they simply found no interest in engineering whatsoever, before or after watching the video. The only response for no or unchanged students that was spoken about the video was the use of math in engineering. Two students mentioned that the involvement of math in the career led them to choose no.

Images that students found interesting (Q6.1) included phones [19], new technologies [8], computers [6], video games [3], medical devices [3], machines [3] and engineers and people working [3]. Thus the pictures found most interesting were those of products that students relate to such as smartphones and computers. Students also found inspiration in images showing young engineers working in the field and images of medical devices. On the other hand, images they did not find interesting (Q7.1) included people holding or using phones [4], labs [2], people helping others with computers [2], and machines [3]. One student also mentioned small devices that appeared complicated as being uninspiring. More students thought pictures of phone were interesting but there was an even like and dislike for pictures of machines.

When asked to give thoughts on the professionals (Q8.1), most students found them informative [41] but some specific positives included how they appeared professional, experience

and enthusiastic [4], and how they made their jobs sound like fun [2]. Some negative feedback included that the professionals were boring [2], that they needed more enthusiasm [1], and that they were confusing [1]. From this we determined that the students had a positive reaction to the professionals and they found them informative. Including them in the video was therefore effective in keeping the students engaged. Also, four students mentioned the professionals as the reason they were encouraged to research more on engineering.

When asked if the video had changed their thoughts on engineering (Q9.1), the majority stated that their views were unchanged [33]. However, eight students mentioned that they now thought that engineering was interesting and that they wanted to know more or get involved. Three students also stated that the video made them realize the importance of engineering. Therefore, the video was successful in encouraging at least half of the students to know more about engineering as indicated by this question and the results of Q5.1. The video was also effective in demonstrating the importance of engineering as seen here and in the answers for Q10.1, which asked students to describe the messages of the video. The most common answers included how much engineering is needed [16], engineering can be fun [6], there are many types of engineering fields [5], and anyone can be an engineer [5]. From this we gathered that the video was successful in conveying many of the intended messages such as anyone can become an engineer, not just exceptional students, and not only is engineering crucial for the wellbeing of people, but it also is a fun job.

Finally, when asked to give overall thoughts on the video, the majority of students thought it was informative [32]. Therefore, this video demonstrated an improvement in conveying specific messages (such as you do not have to be a genius to be an electrical engineer) when compared to the two versions of the chemical engineering video. With these new surveys we could also see that the video was successful in encouraging half of the students to research more about engineering thanks to specific elements of the video such as how it showed that engineers are important for people and the world and the cool technology the they work to produce.

4.7 Summary

Table 4.1 summarizes the messages on the checklist that each video did and did not convey successfully based on survey results. The list of messages is under section 4.2. Table 4.2 shows images and other elements in all videos that students reacted positively and negatively to.

Table 4.1: summary of messages that each video conveyed successfully (marked with a check).

Message	ChE Version 1	ChE Version 2	ME	ECE
1			✔	✔
2				✔
3				✔
4	✔	✔	✔	✔
5			✔	✔
6	✔	✔		✔
7	✔	✔	✔	✔

Table 4.2: Images and other elements of the videos that students reacted to positively and negatively.

Positive Reaction	Negative Reaction
• Images of engineers at work • Images of products that engineers work on • Images of medical related products • Images of modern technology and innovations • Images that had to do with green energy and climate control • Interviewed Professionals were informative • Video length of under six minutes	• Images with confusing math and science concepts • Images of equations or graphs • Pictures that seemed random and not connected to the information presented in the video • Images of confused students • Images that were too industrial • Interview segments in which professionals were confusing and seemed unenthused

From the results presented in this section, it was shown that both versions of the chemical engineering video were unsuccessful in interesting students in engineering while the electrical and mechanical engineering videos were successful in encouraging around half of the students to research more about engineering in their own time. After testing the videos, a solid conclusion about whether the videos actually encourage students to pursue engineering could not be made. What the electrical and mechanical engineering videos were successful at was encouraging students to contemplate about engineering and to do more research on their own time, not to make a decision about a future career. And as shown in table 4.2, the electrical and mechanical engineering videos were for the most part successful in delivering the intended messages while the chemical engineering videos failed at delivering more than half of the message.

5.0 Conclusion

The goal of this project was to inspire middle and high school students to pursue a career in the diverse fields of engineering by creating effective and insightful videos with a particular focus on the various opportunities within each field. The final videos produced for this project were two versions of a chemical engineering video and one version of an electrical and mechanical engineering video. In order to consider each video a success, we looked for an increase in interest towards engineering after students viewed them. In addition we evaluated whether our intended messages were effectively conveyed by each video.

5.1 Chemical Engineering Videos

Neither version 1 or 2 of the chemical engineering videos were successful in encouraging students to think about engineering as a future career. In fact, version 1 encouraged a small number of high school students to not pursue engineering while version 2 also discouraged a small number of middle school students. Neither video was effective in conveying the message that you do not have to be extremely good in math and science to become an engineer either and they were not effective in showing students what chemical engineers specifically do. However, they were successful in convincing students that engineers are important in solving today's real world problems such as quality of life and renewable energy. In addition, although both versions were found informative and educational by a majority of students, they also thought they were boring.

It was found that students react positively to images of products that engineers work on and images of engineers in the work field. They also reacted positively to images of health related things. Therefore, kids enjoyed when engineering was presented through products and the impact they have on people. Yet they reacted negatively to pictures that were focused on math and science. The length of under six minutes was also found to be effective with the majority of students.

5.2 Mechanical Engineering Video

The mechanical engineering video was successful in encouraging half the students that were surveyed to research more about engineering. Students were encouraged because the video demonstrated the impact that mechanical engineers have in the world and society. The video also showed how they work designing and creating cool products, especially medical inventions and military devices. Students were also interested by how the video made the profession seem fun and how it showed that these engineers are creative individuals. The video was also successful in conveying the message that engineers are important in solving today's real world problems such as renewable energy. It was also effective in informing students on what it is that mechanical engineers exactly do. However, this video was not successful in conveying the message that you do not have to be gifted in math and science to become an engineer.

Students reacted positively to including images of products and structures that mechanical engineers work one such as phones, cars, bridges, houses, buildings and military equipment. Therefore, the students find more interest when the profession is presented through the products that these engineers work on and the impact that they have in the world. Images that students did not find inspiring mostly consisted of math equations and graphs, thus it is important to avoid these in the future. Finally, excluding interview segments in this video did not really elicit a noticeable change in student response.

5.3 Electrical Engineering Video

The electrical engineering video was successful in encouraging half of the students to research more about engineering. Students' interest was sparked by demonstrating that engineering has a big impact in the world and health. They were also interested by how engineers work to create cool and modern technology such as phones and computers. Students also found inspiration in the interviewees. The video was also successful in conveying the message that you do not have to be extremely good in math and science to become an engineer. It also conveyed that engineers are important in solving today's problems such as quality of health and technology and that engineering is a fun job. Students who were not encouraged to research more about engineering mostly cited reasons that were not related to the video such as they knew their future careers already or they simply found no interest in engineering.

Including images of products and modern technology such as phones computers and video game consoles incited a positive reaction from students. Students also found the interviewed professionals to be informative, experienced and enthusiastic. The video was also thought to be informative by the majority of students. Compared to our first attempt at editing the chemical engineering videos, this video received a much more positive response overall in terms of entertaining qualities and it was actually successful in meeting the goal of persuading students to think about engineering as a possible career.

5.4 Project Improvements and Future Recommendations

Based on results gathered, the effectiveness of each video can be improved by having more examples of what engineers work on, by being more specific about what engineers actually do and by being more careful in choosing interview segments for the videos. Although in the electrical engineering video, students had a positive reaction to the interviewees, for the chemical engineering versions, the interviewed professional were a main reason why students found the videos were boring. In addition, valuable information on why each video was effective or not could have been gathered earlier by having a better survey. While analyzing the results for both chemical engineering videos, it was found that the data gathered using the initial versions of the pre and post-surveys was not enough to help us formulate why no change was observed from before to after watching the video.

Therefore, when scripting and editing the electrical and mechanical engineering videos, we had to base our decisions solely on what stylistic and informative content students found interesting and informative. We could not improve our videos based on what aspects actually persuaded students to think of engineering as a future career. Thus the surveys were redesigned in order to test the electrical and mechanical engineering videos. With these new surveys we could conclude why the videos were effective in encouraging students to research more about engineering. It is our hope that future groups can expand on this information to either improve these existing videos or to expand the library with other engineering fields.

References

Abbitt III, J. D., & Carroll, B. F. (1993). Applied aerodynamics experience for secondary science teachers and students. *Engineering Education, 82*(3), 185-188.

Aerospace Engineering Collection: Engineer Profiles. *PBS Learning Media.* Retrieved October 14, 2015.

Anderson, L. S., & Gilbride, K. A. (2003). Pre-university outreach: Encouraging students to consider engineering careers. *Global J. of Engng. Educ*, *7*(1), 87-93.

Anderson, L. S., & Gilbride, K. A. (2003). Pre-university outreach: Encouraging students to consider engineering careers. *Global J. of Engng. Educ*, *7*(1), 87-93.

Anderson-Rowland, M. R., Rodriguez, A. A., & Grierson, A. E. (2013). Why Some Community College Students Choose Engineering and Some Don't. *2013 American Society for Engineering and Education Proceedings*.

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. *Journal of Research in Science Teaching*, *47*(5), 564-582.

Ashby Plant, E., Baylor, A. L., Doerr, C. E., & Rosenberg-Kima, R. B. (2009). Changing middle-school students' attitudes and performance regarding engineering with computer-based social models. *Computers & Education,53*(2), 209-215. doi:10.1016/j.compedu.2009.01.013

Becker, F. S. (2010). Why don't young people want to become engineers? Rational reasons for disappointing decisions. *European journal of engineering education*, *35*(4), 349-366.

Brame, C.J. (2015). Effective educational videos. *Vanderbilt University Center for Teaching.*

Capobianco, B. M., Diefes-dux, H. A., Mena, I., & Weller, J. (2011). What is an engineer? Implications of elementary school student conceptions for engineering education. *Journal of Engineering Education*, *100*(2), 304-328.

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-A-scientist test. *Science Education,67*(2), 255.

Colston, N., Thomas, J., Ivey, T., Utley, J., & Ley, T. (2014). Engineer-led Videos: A Broader Impacts Model.

Committee on Prospering in the Global Economy of the 21st Century, National Academy of Engineering Institute of Medicine, National Academy of Sciences, Committee on Prospering in the Global Economy of the 21st Century (U.S.), Ebrary Academic Complete, & Committee on Science, Engineering, and Public Policy (U.S.). (2007;2006;). *Rising above the gathering storm: Energizing and employing america for a brighter economic future*. Washington, D.C: National Academies Press.

Committee on Public Understanding of Engineering Messages, National Academies Press Free eBooks, National Academy of Engineering. Committee on Public Understanding of Engineering Messages, & Ebrary Academic Complete. (2008;2007;). *Changing the conversation: Messages for improving public understanding of engineering*. Washington, D.C: National Academies Press.

Dimopoulos, C., Katzis, K., & Hawwash, K. (2011, September). Attracting students to engineering education studies: a survey of practices. In *Lisbon Congress SEFI (WEE)*.

Engineer Your Life: Dream big. Love what you do. *National Science Foundation, United Engineering Foundation.* Retrieved September 27, 2015.

Engineering: Go for It: Dream Up Your Future, *American Society for Engineering Education.* Retrieved September 27, 2015.

Fralick, B., Kearn, J., Thompson, S., & Lyons, J. (2009). How middle schoolers draw engineers and scientists.*Journal of Science Education and Technology, 18*(1), 60-73. doi:10.1007/s10956-008-9133-3

Guo PJ, Kim J, and Robin R (2014). How video production affects student engagement: An empirical study of MOOC videos. *ACM Conference on Learning at Scale (L@S 2014)*

Ing, M., Tsai, S. M., & Aschbacher, P. R. (2014). Gender differences in the consistency of middle school students' interest in engineering and science careers. *Journal of Pre-College Engineering Education Research (J-PEER), 4*(2), 2. doi:10.7771/2157-9288.1090

Jennings, S., McIntyre, J. G., & Butler, S. E. (2015;2014;). What young adolescents think about engineering: Immediate and longer lasting impressions of a video intervention. *Journal of Career Development, 42*(1), 3-18. doi:10.1177/0894845314555124

Jordan, M. E., & Snyder, J. (2013). Middle school students' conceptions of engineering. Paper presented at the 1945-1950. doi:10.1109/FIE.2013.6685174

Katehi, L., Pearson, G., Feder, M. A., National Research Council (U.S.), National Academies Press Free eBooks, Ebrary Academic Complete. . Committee on K-12 Engineering Education. (2009;2008;). *Engineering in K-12 education: Understanding the status and improving the prospects*. Washington, D.C: National Academies Press.

Klotz, L., Potvin, G., Godwin, A., Cribbs, J., Hazari, Z., & Barclay, N. (2014). Sustainability as a route to broadening participation in engineering. *Journal of Engineering Education*, *103*(1), 137-153.

Lopez-Martin, A., Sanchis, P., Perez-Artieda, G., Gubia, E., Morato, D., Astrain, D., ... & Matias, I. (2013, March). Engineering outreach programs at the Public University of Navarre: A holistic approach. In *Global Engineering Education Conference (EDUCON), 2013 IEEE* (pp. 648-651). IEEE.

Metz, S. S. (2006). What is Engineering and Why Encourage Students to Consider this Field? *National Science Foundation.*

Montfort, D. B., Brown, S., & Whritenour, V. (2013). Secondary Students' Conceptual Understanding of Engineering as a Field. *Journal of Pre-College Engineering Education Research (J-PEER)*, *3*(2), 2.

Nadelson, L. S., & Callahan, J. M. (2011). A comparison of two engineering outreach programs for adolescents.*Journal of STEM Education: Innovations and Research,12*(1-2), 43.

Olson, S., Fagen, A. P., National Academies Press Free eBooks, National Research Council (U.S.). Board on Life Sciences, & Ebrary Academic Complete. (2007;2006;).*Understanding interventions that encourage minorities to pursue research careers: Summary of a workshop*. Washington, D.C: National Academies Press.

Safferman, A. G., Jeffers, A. T., & Safferman, S. I. (2004). Understanding K-12 engineering outreach programs.*Journal of Professional Issues in Engineering Education and Practice, 130*(2), 95-108. doi:10.1061/(ASCE)1052-3928(2004)130:2(95)

Samuels, K., & Seymour, R. (2015, March). The middle school curriculum: engineering anyone? *Technology and Engineering Teacher*, *74*(6), 8+.

Sandrin, S., & Borror, C. M. (2013). Student perceptions and interest in engineering: Effects of gender, race/ethnicity, and grade level. Paper presented at the ASEE Annual Conference and Exposition, Conference Proceedings, 2013.

Weavers, L. K., Bautista, D. T., Williams, M. E., Moses, M. D., Marron, C. A., & La Rue, G. P. (2011). Assessing an engineering day camp for middle-school girls. *Journal of Professional Issues in Engineering Education and Practice,137*(3), 127-134. doi:10.1061/(ASCE)EI.1943-5541.0000046

Wentling, R. M., & Camacho, C. (2008). women engineers: Factors and obstacles related to the pursuit of a degree in engineering. *Journal of Women and Minorities in Science and Engineering, 14*(1), 83-118. doi:10.1615/JWomenMinorScienEng.v14.i1.50

What is Engineering? Faculty of Engineering and Built Environment. *The University of Newcastle (UON), Australia.* Youtube, Retrieved September 27, 2015.

What's an Engineer? Crash Course Kids #12.1. *Crash Course Kids.* Retrieved October 14, 2015.

Why Study Engineering? *Engineering Yeah.* Youtube, Retrieved October 14, 2015.

Wyss, V. L., Heulskamp, D., & Siebert, C. J. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental and Science Education*, *7*(4), 501-522.

Yoder, Brian L. (2014), Engineering by the Numbers. *American Society for Engineering Education.* Retrieved September 27, 2015.

Yurtseven, H. O. (2002). How does the image of engineering affect student recruitment and retention? A perspective from the USA. *Global J. of Engng. Educ*, *6*(1), 17-23.

Appendix

Appendix A- Videos that Were Studied and Used as Reference

What Most Schools Don't Teach
-Youtube channel: Code.org

This video is more about computer science and coders but it has motivational elements that can be applied in our videos about engineering. This video emphasizes the fact that coders don't have to be geniuses to become successful. They just have to be determined. This video also explores how engineering and coding is ultimately for the benefit of people. The video also shows multiple and diverse "visual role models" who are young and seem very exciting and interesting.

Why Study Engineering
-Youtube channel: EngineeringYeah

This video wants to encourage students to study engineering by mostly showing the technologies that engineers work on. It does not go into a into a lot of detail about the specific fields of engineering and what engineers specifically do but it mentions that they are crucial for solving environmental and social problems which is an aspect we want to focus on. It employs one of the Changing the Conversation taglines: "Turn ideas into reality" (modified version). By taking emphasis on technological items, the video lacks visual examples of young and diverse engineers working in the field.

What's an engineer? Crash Course Kids #12.1
-Youtube channel: Crash Course Kids

This video goes into more detail about what an engineer is in general and it talks about what specific engineers do briefly. However, it does not make an effort to correct a lot of misconceptions that young student hold about engineering. For example the narrator mentions that mechanical engineers make engines and cars etc instead of saying that they design them. This video also emphasizes only on the problem solving aspect of engineering and although it relates to societal problems, it does not go into detail on how engineering is essential for our health and happiness. However, the video is successful in providing young students with examples of projects that engineers do.

Engineering Education Makes a World of Difference
-Website: engineeringaworldofdifference,org

This website is meant to offer resources to students about engineering. It has a line of videos designed to show students that engineers can make a difference in the world. However, the videos don't go into detail about what the specific engineers do. They don't provide the name of the engineer they are talking about and it gives the videos an impersonal feel that would not seem approachable to young students. They are not truly showing students relatable examples of successful engineers. The videos are also extremely short and they are not done in a format that is attractive to young students.

Marquette's Engineering Hall: Engineers for Today's World Problems
-Youtube channel: MarquetteU

More of a promotional video for the school but it presented many of the world problems in which engineers are crucial for solving them. Therefore it appeals to students who want work in

areas such as health and green energy. The video also emphasizes skills that engineers need that are not learned in school such as communication and creativity. However, the video is pretty vague and it does not go into specifics about what engineers specifically do to solve these problems.

What is Engineering?
-Youtube channel: UON FEBE

The video gives a brief overview of what engineering is and what engineers do. It is well formatted and specifically made for younger audiences by presenting all the concepts they speak about with doodled images. Although the video presents multiple examples of the kind of problems that engineers solve, such as the bridge spanning the Sydney Harbor, it avoids using higher level terms that could confuse young students or even scare them. The video also emphasizes how engineers solve problems to make the world a better place and to improve people's quality of life although they don't really present examples that are directly related to climate change or health. Also, the video does not really touch on the many engineer fields there are and what career opportunities there are in each of them.

Engineer Your Life
-website: engineeryourlife.org

The videos on this website are an excellent source of "visible role models" for young girls. The videos also focus on how the problem solving aspect of engineering helps improve health, the community and creativity. It also demonstrates to students that engineers need many skills that are not related to math and science such as creativity, communication and teamwork. It also presents engineering as a social career and does very well in straying from the typical image of an engineer working in a cubicle all day.

Aerospace Engineering Collection
-website: pbslearningmedia.org

This collection of videos presented by Boeing Corporation and PBS Learning Media provides multiple mechanical and aerospace engineer profiles. These videos dispel many of the engineering stereotypes and they emphasize tremendously in the collaborative aspect of the career. The videos are mostly for providing relatable "visible role models" for a wide array of students.

Engineering: Go for it!
-website: egfi-k12.org

The interview videos with professionals and engineering students in this website care was taken to include a varied population of engineers based on gender, racial and ethnic background. The videos were mostly for providing "visual role models" and not for dispelling many of the misconceptions about engineering or giving more information about what the engineers do. This is mostly done by the website through small written summaries for each engineering field.

Appendix B - Final Video Scripts

Appendix B-1: Chemical Engineering V.1 Final Script

INTRO

Chemical engineers play an immense role in our everyday lives, in many ways most of us don't even realize. They work to develop materials such as plastics for multiple applications like injection pens for type 1 diabetics.

Interview Clip: Anne introduces herself

From food and fuel, to plastics, chemical engineers design the process which go to creating their product. They can also design processes that maintain desirable outcomes. For example, chemical engineers are involved in making sure that the emissions from power plant smokestacks are within the Environmental Protection Agency's regulations.

Interview Clip: Nikki introduces herself and talks what she does.

HOW

Chemical engineers complete their projects by combining key principles of chemistry, physics, and mathematics. They apply these concepts to create a process which will result in the desired product or outcome. These products include cosmetics, petroleums, synthetic fibers, foods and more.

Chemical engineers can also apply their knowledge in other fields such as biomedical engineering.
For example, they can apply the concept of fluid mechanics to help understand biological processes to help in the production of medical drugs and devices.

Interview: Anne talks about fluid dynamics and blood

WHAT/WHO

But who exactly is a chemical engineer?
On paper, it may seem that it takes a genius to make the visions of chemical engineers possible, however the important thing to realize is that their skills are learned over years of experience.

Another important distinction is that between engineers and scientists. Where a scientist studies their particular field, such as physics or chemistry in great detail, the engineer will learn enough about each of the topics to combine them and make their ideas come to life.

Interview: either of them talking about difference between scientist and engineer

CONCLUSION

With process design and scientific principles brought together, chemical engineers continue to make possible huge advancements in green energy, food safety, and structural integrity.

Interview: Nikki talking about how important engineering is

Appendix B-2: Chemical Engineering V.2 Final Script

Every day, professionals around the world go to work to improve everything we use in our daily lives. Often their work goes unnoticed, or isn't fully understood. They are the modern day's unsung heroes. They are engineers. (17 s)

Chemical engineers combine knowledge of the physical sciences with some math and economics to produce, transform, and properly use chemicals, materials and energy. We sat down with a couple professionals to get their observations about what it's like to be a chemical engineer. (17 s)

Professional intros (16s and 21s) vids 00017 and 00023

A common misconception about chemical engineering is that they must only deal with chemicals, typically like we think about acids or other liquids. However, the profession is actually much broader, covering topics such as food, fuel, eco-friendly advancements, and medical devices. (18s)

Vid 00018 time 00:00:54-00:01:14 (20s)

Vid 00024 time 00:00:19-00:00:27 and 00:01:03-00:01:13 (16s)

Amazingly, given the vast assortment of sub areas in which chemical engineers can find themselves, they often follow similar procedures across all specialties to accomplish their goals. The public misunderstanding of engineers is that they do similar work to scientists. Our professionals point out the crucial differences. (20s)

Vid 00018 time 00:01:49-00:02:12 (23s)

Vid 00025 time 00:00:05-00:00:27 (22s)

Now that we know a little more about what they do, a good question to ask is who can be a chemical engineer? And the answer is really anyone who puts in the effort. Our professionals also told us a few traits they believe makes a great engineer stick out amongst everyone else. (16s)

Vid 00018 time 00:02:21-00:02:35 and 00:03:02-00:03:14 (26s)

Vid 00026 time 00:00:55-00:01:06 (11s)

With process design and scientific principles brought together, chemical engineers continue to make a world of difference in green energy, food safety, medicine, and so much more. Advancements in their work not only gives us new products every day, but also helps to make our world a safer place to live.

Appendix B-3: Electrical Engineering Final Script

Messages that we want to convey:

- electrical engineers work creating cool products
- electrical engineers are crucial for the health and wellbeing of people, they work to solve many of the health problems of today
- electrical engineers are cool and exciting people and they don't have to be geniuses to become engineers

Intro:
Think about what you use on a daily basis. The objects you use daily seem to fit in your pocket or can be carried around in your backpack and can give you access to so much information with just the push of a button. Objects like your phone, tablets and computers. Heck, you're using a computer right now to watch this video and everything in your home is powered by electricity. All of these modern devices that make our lives so much easier are brought to you thanks to electrical and computer engineers.

Here are some professionals that can give us some insight on what it's like to be an electrical engineer.

Who/what/how:
So who are these people behind much of the technology we use today? Electrical engineers work every day to design, develop, test and supervise the manufacturing of electrical equipment. They use concepts of electricity to solve problems related to energy, power, information processing and communication.
Electrical engineers that work in energy are tasked with making sure that your home never loses power even during big storms! Other electrical engineers work in the design and development of cool products such as your phone, computer, televisions, video game consoles and virtually all other electronics that you use daily.
They also play a big role in health and medicine thanks to products such as heart rate and blood pressure monitors and other devices that allow doctors to easily take care of their patients and to diagnose diseases. This goes to show that without engineers, today's healthcare would not be the same.
/*Speak about the interesting points said by the interviewees for middle of video*/

Conclusion:
So now we know who these engineers are, what they do, and how they do it. But what can you do if you wanna become an electrical and computer engineer and turn your creativity into a change that will benefit the world. Engineering is a broad field in which anyone can succeed. Talking to your teachers and school counselors can help you figure out how you can prepare to become an engineer. (List ideas such as talking to teachers, counselors, listing a few companies to look up, or show interview clips if interviewees came up with something).

Outro:
Engineering offers so much and it contains many fields that interest different people. All engineers are important in improving the wellbeing of communities around the world. Electrical engineers help make the world a better place thanks to advancements in technology and communication.

Appendix B-4: Mechanical Engineering Final Script

Intro:

*Background imagery of engineering symbols, such as those mentioned in the intro speech. Fade in of questions such as *Who are Engineers*, *What do Engineers do*, *How do Engineerins impact the world*, *Can I be an Engineer*, finishing on solid: **Who are: Mechanical Engineers?***

Spoken over intro: "Living everyday among the rest of us, disguised as average civilians, are modern day inventors, problem solvers, and creative thinkers, making everything we interact with everyday a possibility. From the design of a rover destined for Mars, to the devices made to clean your water supply, to making roads and buildings safe for us all, who are these amazing people? They are: Engineers."

Body:

Mechanical engineering is the field in engineering with its roots in the physical properties of systems: How things move, and why. The field is astoundingly diverse and there are few limitations to where they can apply their skills.

Insert snip-it of interview question 1.

Mechanical engineers have made parts for NASA spacecraft, designed machines and machine parts, made advancements in automotives and other modes of transportation, and even take part in newer medical advancements with prosthetics.

Insert snip-it of interview questions 2 and 3.

Where mechanical engineers are different to materials scientists is in the work they do revolving around materials. A scientist will invent new materials, quantifying its properties and finding different methods of making it. An engineer will then come in and find new ways to apply that material to a project to make something more efficient, cost effective, etc. (Interview question 4)

One of the largest areas in which mechanical engineers apply their knowledge to improve society is in travel. Making cars, airplanes and trains more efficient, cost less, and save money by making them more aerodynamic makes a world of difference as we continue to move forward.

Tackling a project in mechanical engineering often starts with a solid definition of the problem. "Car fuel efficiency". Then they work out the physical properties which have some effect on the problem. "Engine flaws, aerodynamics of the vehicle, resistance of the tires". Then, using some equations learned in school, they come up with possible new designs to make improvements. "More accurate engine creation, new metals, different rubbers, new vehicle designs". Next, they make prototypes and test their hypotheses. Finally, they analyze the results, learning from both positive and negative results what works and what does not.

Conclusion:

Mechanical engineers play an important role in information gathering and idea generation to continue to make things run smoothly. With a little math and some skills to craft items never before thought of, Mechanical engineers are continuing to build some of society's greatest advancements in travel, medicine, and space exploration.

Appendix C- Pre and Post-Survey Raw Data

Appendix C-1: Raw Data: Chemical Engineering Videos Versions 1 and 2, High School Students

		Strongly Agree	Agree	Disagree	Strongly Disagree
Question 1	Pre	32 (students)	112	42	7
	Post 1	9	49	25	2
	Post 2	18	58	19	4

		SA	A	D	SD
Question 2	Pre	107	82	4	0
	Post 1	72	13	0	0
	Post 2	67	32	0	0

		SA	A	D	SD
Question 3	Pre	116	76	1	0
	Post 1	66	18	2	0
	Post 2	67	32	0	0

		SA	A	D	SD
Question 4	Pre	72	102	17	2
	Post 1	29	43	13	0
	Post 2	24	58	15	0

		SA	A	D	SD
Question 5	Pre	21	58	73	41
	Post 1	7	24	36	18
	Post 2	12	30	38	20

		Engaging and Entertaining	Boring	Educational	Too long	Too short
Question 6	Post 1	31	15	71	4	7
	Post 2	42	13	85	5	9

Appendix C-2: Raw Data: Chemical Engineering Video Version 2, STEM Saturday

		Strongly Agree	Agree	Disagree	Strongly Disagree
Question 1	Pre	21	27	1	0
	Post	26	21	1	1

		SA	A	D	SD
Question2	Pre	32	16	1	0
	Post	36	12	1	0

		SA	A	D	SD
Question3	Pre	34	15	0	0
	Post	31	18	0	0

		SA	A	D	SD
Question 4	Pre	11	23	13	2
	Post	13	18	16	2

		SA	A	D	SD
Question 5	Pre	23	19	5	2
	Post	22	17	8	2

		Engaging and Entertaining	Boring	Educational	Too short	Too Long
Question 6	Post	26	12	42	13	3

Appendix C-3: Raw Data: Electrical Engineering Video, 7th and 8th Graders

		Strongly Agree	Agree	Disagree	Strongly Disagree
Question 1.1	pre	6	33	17	0
	post	7	29	17	3

		SA	A	D	SD
Question 2.1	pre	28	23	5	0
	post	33	22		1

		SA	A	D	SD
Question 3.1	pre	13	26	16	1
	post	11	21	22	1

		SA	A	D	SD
Question 4.1	pre	6	13	26	11
	post	NA	NA	NA	NA

		Teamwork	Strong in Mathematics	Communication	Individual Problem Solver	Leadership
Question 5.1	pre	37	26	28	7	10
(Q4.1 post)	post	30	28	24	8	8

		Time Management	Creativity	Strong in Science	Working at computer all day
Question 5.1	pre	10	30	8	2
(Q4.1 post)	post	5	36	14	3

		Strong Writing	High IQ	Multitasker	Design Skills
Question 5.1	pre	1	2	7	23
(Q4.1 post)	post	3	6	7	25

Appendix C-4: Raw Data: Mechanical Engineering Video, 7th and 8th Graders

		Strongly Agree	Agree	Disagree	Strongly Disagree
Question 1.1	pre	8	42	9	2
	post	13	36	9	2

		SA	A	D	SD
Question 2.1	pre	21	38	2	0
	post	36	20	3	0

		SA	A	D	SD
Question 3.1	pre	14	27	16	3
	post	13	32	11	4

		SA	A	D	SD
Question 4.1	pre	7	13	31	10
	post	NA	NA	NA	NA

		Teamwork	Strong in Mathematics	Communication	Individual Problem Solver
Question 5.1	pre	48	18	30	4
(Q4.1 post)	post	33	19	32	13

		Leadership	Time Management	Creativity	Strong in Science	Working at computer all day
Question 5.1	pre	17	8	32	6	1
(Q4.1 post)	post	11	5	34	8	0

		Strong Writing	High IQ	Multitasker	Design Skills
Question 5.1	pre	0	3	11	25
(Q4.1 post)	post	1	2	8	27

Appendix D – Final Videos

Links for the final videos are included under Gordon Library's IQP project report database.