Inspiring Future Engineers in the Borough of Merton

London, England

An Interactive Qualifying Project Report submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science in cooperation with the Commonside Community Development Trust

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Abstract

The United Kingdom's engineering sector has vacant positions and there are not enough skilled workers to fill them. The Commonside Community Development Trust hopes to inspire local students to pursue engineering by starting a community-wide outreach initiative. To ensure that Commonside has the proper materials and information to effectively implement this outreach initiative we completed three objectives. We determined reasons why students in the London borough of Merton were not choosing engineering as a career. We outlined engineering outreach programs that incorporate Merton history and influential engineers who lived in the borough. We provided the Commonside Community Development Trust with recommendations for approaching private-sector companies with the intent of forming partnerships.

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Executive Summary

The United Kingdom's engineering sector is currently failing to fill vacant positions with qualified workers. According to the Centre for Economics and Business Research the number of vacancies in the UK engineering sector will increase by 257,200 between 2012 and 2022. These vacant positions would contribute £27.0 billion in Gross Domestic Product (GDP) if filled (Centre for Economics and Business Research, 2014). The growing shortage of qualified engineers in the UK is a threat to the UK economy.

The director of the Commonside Community Development Trust proposed an initiative to increase engineering education in east Merton. East Merton, specifically Pollards Hill where Commonside is located, has a high rate of unemployment and deprivation (London Borough of Merton, n.d.a). Commonside's director proposed this initiative with the goal of helping local residents capitalize on the growing number of vacant positions within the engineering sector. Our role was to provide information and resources to help Commonside effectively implement the initiative. In order to accomplish our goal we developed three objectives:

1. To evaluate the current interest in and state of engineering education in east Merton.
2. To draft engineering outreach programs that incorporate the local history of the London Borough of Merton and the influential engineers who lived there.
3. To provide recommendations for engaging potential supporters and partners for the proposed initiative.

Background

The United Kingdom is falling behind in three areas relevant to engineering growth: employment, number of new engineering graduates, and research and development spending. The growth of the engineering workforce in the United Kingdom is small relative to other developed nations such as the United States, Germany, and France (Marriot, 2006).

Reports from the Higher Education Statistics Agency (HESA) revealed that the number of students graduating with engineering and technology degrees in the UK dropped by 10% from 1995 to 2004. It took until 2014 for the number of students graduating with engineering and technology degrees to grow back to where it was in 1995. During this time the number of other undergraduate SET degrees awarded was increasing (Higher Education Statistics Agency, 2015). The UK spends only 1.7% of its GDP on research and development whereas the US and Germany each spend nearly double that percentage (Department for Business, Innovation and Skills, 2014).

Organizations in the UK have made efforts to create future engineers. EngineeringUK and Young Engineers, both based in London, are the two largest of these organizations. EngineeringUK runs an outreach effort known as the Tomorrow's Engineers program. In this program, EngineeringUK uses in-school workshops, hands-on activities, mentorship programs, and engineering career fairs to expose students to engineering and inspire future engineers (EngineeringUK, n.d.b). Young Engineers offers schools the option to host STEM Challenge Events where they give students a problem to solve and challenge them to design and build a solution (Young Engineers, 2016b).

The London Borough of Merton was formed in 1965 when the municipal boroughs Mitcham, Morden, Merton, and Wimbledon merged. Merton had a large number of manufacturing companies along the River Wandle during the industrial revolution due to the usefulness of the river's fast flowing water. During its success, Merton attracted many wealthy residents (Merton Council, n.d.a).

Methodology

To complete our first objective we created a survey for students and interviewed local school teachers and administrators. We distributed the survey through events hosted at Commonside as well as to St. Mark's Church of England academy. We interviewed two members of the school's senior leadership team, Senior Vice Principal Austin Sheppard and Vice Principal Jonathan Harris, and the school's IT coordinator. In our survey and interviews we gathered information that we could use to determine which groups of students Commonside

should target in the initiative, what kinds of outreach programs would be most effective, and how receptive students, teachers, and administrators would be to Commonside's initiative.

To complete our second objective we conducted interviews with experts from local historical societies to learn more about local industrial history that we could incorporate into potential outreach programs. We interviewed representatives from the Wandle Industrial Museum and the Merton Heritage Society. Using the information we gained from these representatives we conducted independent research to continue learning about local history that could be useful in outreach programs. We then developed draft engineering outreach programs which incorporate the history we researched.

To complete our third objective we conducted interviews with representatives from local companies and organizations. We chose these representatives either because their company or organization was a prospective partner for the initiative or because they had experience forming successful partnerships. Through these interviews we determined what private sector companies would look for in a partnership with a charity organization.

Results and Recommendations

Students are interested in exposure to engineering education yet are not choosing engineering as a career. We found that students were in favor of engineering but only considered the field as a tolerable career choice, rather than ideal. Most students had never been recommended a career in engineering by an adult and had not participated in any engineering related activities outside of the classroom. We determined exposure to engineering related activities, programs, and demonstrations, and having an adult recommend engineering as a career were two major reasons why students were interested in engineering as a career. We made recommendations to Commonside to include parents in engineering outreach programs so that parents' opinions of engineering as a career could be affected as well as students' opinions.

We drafted engineering outreach programs incorporating the local history of Merton and important historical engineers from the borough which we suggest Commonside further develop into complete outreach programs for students. We considered several aspects of local industrial

history and determined which parts of this history would be suitable for engineering outreach programs. The local Merton Abbey Mills still has a working waterwheel that would be a useful addition to an outreach program. Utilizing the textile printing techniques employed in the Merton Abbey Mills would be a useful method to connect science and technology to arts by teaching students creative design skills. Wandle Industrial Museum volunteers were willing to incorporate engineering principles into their existing historical outreach programs. We determined that we could incorporate the accomplishments of local engineers into outreach programs and outlined programs based on famous railway bridges designed by Merton resident James Brunlees, a well-respected civil engineer and a program based on Joseph Bazalgette, a Merton resident and the engineer who designed the modern London sewer system.

We created recommendations for Commonside to use when attempting to form partnerships with private-sector companies. We used information from our interviews with company representatives and individuals with experience forming partnerships to determine benefits that Commonside could bring to a partnership with a private-sector company. We also determined what Commonside should look to gain from these partnerships.

Table of Contents

1.0 Introduction

Due to a lack of new engineers joining the workforce, organizations throughout the United Kingdom have set out to improve engineering education and increase engineering outreach to primary and secondary school students. From 1995 to 2004, the number of university students in Great Britain who graduated with engineering degrees dropped 10% from over 23,000 to fewer than 20,000 per year while other science and technology degrees like biology, architecture, medicine, and chemistry increased an average of 57% over the same time period (Marriot, 2006). Over the next decade, Great Britain saw a gradual increase in the number of new engineers and by 2013 the number of graduates reached 25,000 per year, similar to the number in 1996. Despite positive growth, the increase in engineering graduates was small in comparison to graduates with degrees related to biology and medicine which increased from 25,000 to over 40,000 per year over the same period (Higher Education Statistics Agency, 2015). This trend raises concerns about the future of the engineering sector of the UK job market. By the year 2022, the Centre for Economics and Business Research (CEBR) estimates that there will be an additional 257,200 engineering vacancies throughout the UK, 57,000 of which are in London alone. If filled, these vacant positions will account for a £27 billion increase in the gross domestic product (Centre for Economics and Business Research, 2014). With the decreasing number of engineering graduates in Great Britain these positions are in danger of remaining vacant and the UK will lose out on potential benefits.

To address the lack of new engineers, researchers and organizations have developed methods to design outreach programs to inspire children to pursue a career in engineering. The two most popular engineering outreach methods involve performing in-class demonstrations and organizing engineering design contests. In-class and after-school demonstrations called “road shows” are designed to teach students about science, math, and technology through interactive experiments. Other organizations increase interest in engineering by hosting engineering design competitions where students are given a problem and must plan, design, and build an innovative solution (Jeffers et al. 2004). EngineeringUK and Young Engineers, the two major national engineering outreach organizations in Great Britain, have used these methods in their outreach efforts. Through their “Tomorrow’s Engineers” program, EngineeringUK, a nonprofit outreach organization, has increased interest in engineering by 8% as well as doubling the number of

students who understand what an engineering profession entails from 25% to 50% among program participants (EngineeringUK, n.d.b). Similar to EngineeringUK the organization Young Engineers has influenced over one million students in their 23 year existence with their outreach efforts, primarily with their STEM design challenge events and large scale engineering design contests (Young Engineers, 2016a).

While outreach efforts on the national scale exist, these programs are not currently available everywhere. Since every community that sees the need for engineering outreach may not have access to national programs, local organizations must start their own small-scale efforts. The Commonside Community Development Trust, an organization located in the London Borough of Merton founded with the mission to create a better future for the local community, hopes to bring engineering to students in East Merton. Commonside plans on starting an outreach initiative partnering with local technology companies to provide engineering outreach opportunities to local children. With this initiative, Commonside hopes to create a community-wide interest in engineering and to convince schools to put a greater focus on science, math, engineering, and technology education in their curricula.

The goal of this project was to provide information and resources to help the Commonside Community Development Trust effectively implement their proposed initiative to promote engineering education in the Borough of Merton. Our team identified three objectives required to accomplish this task. The first objective was to evaluate the current interest in and state of engineering education in the local community to determine the best demographics on which to focus future outreach efforts. The next objective was to develop draft engineering outreach programs to incorporate local history and heritage into Commonside's initiative to increase community interest and participation. Our final objective was to create recommendations about how to engage potential supporters and partners of the proposed initiative to help Commonside effectively collaborate with companies who showed interest in engineering outreach efforts. With our project we created a foundation for Commonside Community Development Trust to plan and execute effective engineering outreach programs in the local Merton community.

2.0 Background Literature Review

The Commonside Community Development Trust wants to promote engineering within the London borough of Merton. This desire stems from the lack of engineers within the UK as a whole. This chapter goes into detail about why this problem is a concern to the UK and to Merton. This chapter also focuses on existing engineering outreach programs and how to evaluate them. The conclusion of this chapter provides background information on Merton and provides details about Commonside's reason for involvement in this issue.

2.1 Engineering in the United Kingdom

The United Kingdom is experiencing a shortage of engineers. The nation is seeing a decreasing number of new engineers entering the workforce and researchers predict within a decade there will be over a quarter of a million engineering jobs left vacant (Machin, 2006; Centre for Economics and Business Research, 2015).

2.1.1 Plenty of Jobs, No Engineers to Fill Them

The UK does not have enough qualified engineers to fill all open engineering positions, which presents a problem for the economy. The number of people employed in engineering enterprises in the UK declined by 7.9% between 2009 and 2013, falling from 5,895,000 to 5,431,000 (EngineeringUK, 2015). This decline negatively affects the UK since its engineering sector is still struggling to fill vacant positions with qualified workers (Centre for Economics and Business Research, 2014). In 2014, the contribution to the UK's GDP from engineering was 27.1% (Centre for Economics and Business Research, 2015). With engineering already being such a large component of the economy, it is clear that a shortage of engineers in the UK is an issue. Not only does the shortage affect the current job market, but engineering is also growing worldwide. With the number of job opportunities in engineering on the rise, it is of even greater concern to the UK to eliminate the shortage of engineers (EngineeringUK, n.d.a).

The current shortage of engineers can also have an effect on the UK economy. Centre for Economics and Business Research (2014) projects there will be 257,200 more engineering positions within the UK in 2022 than there were in 2012, which could account for an additional £27.0 billion in Gross Domestic Product (GDP). Table 1 shows the estimated number of vacancies in the engineering sector by region, as well as the projected loss of GDP should the vacant positions not be filled. The Centre for Economics and Business Research (CEBR) estimated that there will be 59,000 new vacancies in London by 2022 (Centre for Economics and Business Research, 2014).

Table 1. Expansion of demand for engineers and projected impact on GDP in 2022

Region	Expansion demand '000s	2022 GDP forecast £ million
London	59	8,288
South East	67	7,120
East of England	29	2,767
South West	25	2,209
North West	20	1,745
Scotland	18	1,667
East Midlands	14	1,168
West Midlands	7	595
Yorkshire & the Humber	6	533
Wales	5	367
North East	3	268
Northern Ireland	3	255
UK	257	26,983

Source: (Centre for Economics and Business Research)

Engineering education is vital not just to the UK economy, but to the people of the UK as well. Nearly one million UK citizens from age 16 to 24 are unemployed (Perkins, 2014). This number could be lowered if more citizens of this age group were qualified engineers who could take the vacant positions in the engineering sector. Many engineering jobs in the UK are currently being filled by immigrants as well. This presents a large problem to the UK since not only are engineering jobs remaining vacant, but up to 20% of people filling these positions are from other countries (Perkins, 2014). The engineering sector has nearly twice as many hard-to-fill vacancies at the professional and skilled trade levels as other sectors (Centre for Economics and Business Research, 2014). An increased focus on engineering education within the UK would be able to help reduce the number of unemployed citizens by giving them the skills to fill

these vacancies. Increasing focus on engineering would also help reduce the UK's dependency on immigrants to fill engineering jobs.

2.1.2 The UK is falling behind in Engineering

The United Kingdom has long been a leader when it comes to engineering. British engineers and technicians were some of the best in their respective fields and known throughout the world. In recent history this picture started to change. Despite a shift in the global economy that favors engineering, Professor John Perkins, the chief scientific advisor for the UK Department for Business Innovation & Skills, fears that in the country's current state Great Britain will miss out on many of the potential opportunities brought on by this change in the global market (Perkins, 2014). This statement by Professor Perkins is not unfounded; data gathered from surveys conducted by the UK government and private research organizations suggests that the growth of the engineering workforce in the United Kingdom is small relative to other developed nations (Marriot, 2006; Department for Business, Innovation, and Skills, 2014).

Compared to several other countries the United Kingdom is beginning to fall behind in areas such as numbers of engineers employed in the workforce, numbers of students graduating with engineering degrees, and amount of research funding. These statistics focus on comparing the UK to the United States, Germany, and France. The UK is a developed nation with a social and work culture similar to the United States, Germany, and France. Comparisons between these countries are more meaningful than comparing the UK to countries with entirely different social and work cultures such as Japan, China, and India. Marriot (2006) reported that data collected from the National Labour Force Survey showed that only 5.5% of the United Kingdom's workforce was employed in science, engineering, and technology (SET) fields. This report also notes that this percentage is similar to that of France, but noticeably lower than Germany, which has 6.1% of its workforce employed in SET jobs (Marriot, 2006). In addition, a March 2015 report stated that in the United States there were over 8.3 million people employed in STEM related jobs, which accounted for 6.2% of the workforce (Bureau of Labor Statistics, 2015). According to this data, the UK now employs a smaller percentage of their workforce in science, technology, engineering, and mathematics (STEM) jobs compared to the US and Germany, who

have historically been the UK's direct competitors in technology. The smaller relative workforce, combined with the large number of vacant engineering jobs, implies that this percentage may further decrease and the UK may struggle to keep up with the technology output of the United States and Germany.

Marriot (2006) also provided statistics on the number of students obtaining SET degrees in Great Britain. From 1995 to 2004 the number of undergraduate SET degrees awarded had a fairly sizeable increase of about 57%. Despite this large increase in overall SET degree graduates, students graduating with engineering and technology degrees dropped 10% over the same period, as shown in Figure 1 (Marriot, 2006). Over the nine year period from which these data were gathered engineering went from the most popular SET degree amongst new graduates to the fourth highest. It took ten years for the number of students graduating with engineering and technology degrees to surpass the 24,000 student per year peak set in 1995/96, with 25,000 students graduating in 2013/14. By this time, the number of students graduating with medicine and biological sciences far surpassed the number of engineering graduates with both subjects having around 40,000 graduates per year in Great Britain (Higher Education Statistics Agency, 2015). The decline in undergraduate degrees is a problem given the current and future labour shortages.

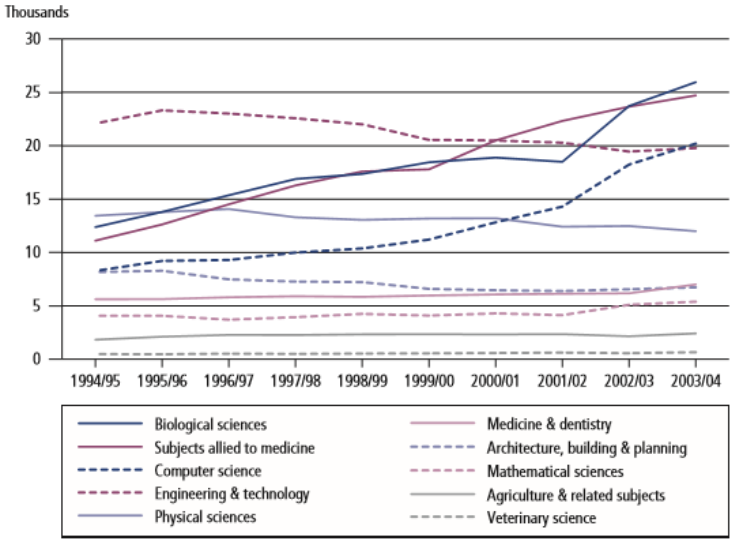

Figure 1. Number of New SET Degree Graduates in Great Britain from 1995 to 2004

Source: (Marriot, 2006)

Even when engineering was the most popular SET degree awarded, the United Kingdom again trailed behind Germany in percentage of students graduating with engineering degrees. Machin (2003) compared male and female students of several majors in the UK and in Germany. According to the Labour Force Surveys in the respective countries, there was a major gap between the UK and Germany in the percentage of graduates who majored in engineering. In 1996, 18.5% of male and 1.5% of female students graduated with an engineering degree in the UK. For males in Germany this number was considerably higher, with 26.3% of university students graduating with an engineering degree. Germany also had double the percentage of female graduates with 3.3% of female students graduating with an engineering degree (Machin, 2003). As the decline in engineering degree graduates does not seem to be driven by a lack of job opportunities in the UK (see section 2.1.1), these data imply that in the UK there may be a lack of interest in joining the engineering field. These data provided by Machin (2003) support the contention that engineering in the UK is falling behind engineering in the United States and Germany.

Alongside employment and education, research and development (R&D) is an integral part of growth in a country's engineering sector. Research and development investment is essential to a country's technological advancement as it allows companies to continue to pursue new innovations. Pursuing innovation not only promotes technological advancement, but it also helps the advancement of the individual business. According to the National Endowment for Science Technology and the Arts (NESTA), an organization promoting innovation in the UK, businesses that focus on innovation grow twice as fast and are less likely to fail (Department for Business, Innovation and Skills, 2014). Without adequate research funding no country can expect to compete in the global technology market; this fact has important implications for the overall economy of the UK.

In a report about the current status of innovation in the UK, the Department for Business, Innovation and Skills (2014) compared R&D funding in the UK to other large industrial nations. The Department for Business, Innovation and Skills (2014) cites data from the Organisation of Economic Co-operation and Development (OECD) which states that compared to the rest of the world, the UK ranks seventh with 3% of total R&D spending with 27.4 billion GBP invested in

2011. Most notably the UK ranks far behind the United States with 30% of total spending, China with 16%, and Japan with 12%. Comparing raw spending may be misleading since spending is generally tied to the size of a country's Gross Domestic Product (GDP). For a more accurate comparison between the United Kingdom and other leading innovators, Figure 2 provides the total R&D spending of each country quantified by percentage of their GDP.

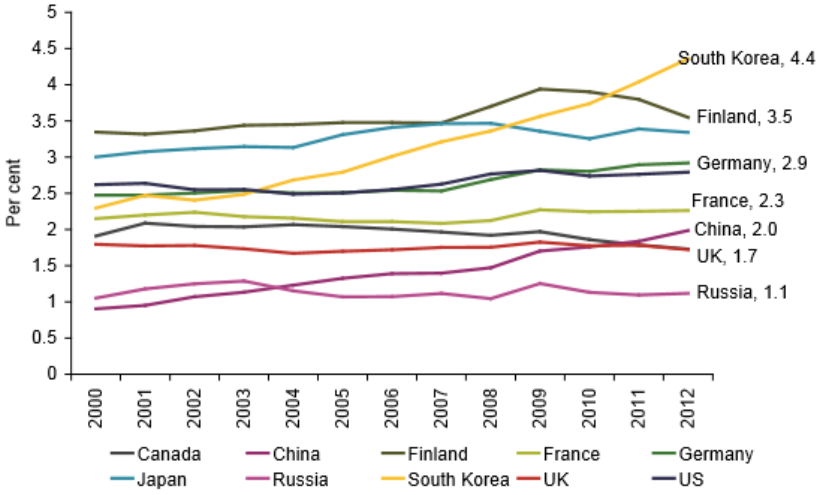

Figure 2. Gross Expenditure on R&D as a share of GDP 2000-2012

Source: (Department for Business, Innovation and Skills 2014).

Taking into consideration the size of the United Kingdom's GDP, the country is ranked fifth with only 1.7% of their GDP spent on R&D. In the US and Germany, this percentage is nearly doubled, with both countries investing 3% of their GDP towards R&D (Department for Business, Innovation and Skills, 2014). The low percentage of R&D funding by the UK has affected businesses. The Department for Business, Innovation and Skills (2014) reports that 30% of businesses that do not innovate attribute their choice to excessively high costs and high risk. The lack of R&D funding caused the United Kingdom to lose out on innovation opportunities and further fall behind the United States and Germany in engineering.

The UK has fallen behind in three areas relevant to engineering growth: employment, number of new engineering graduates, and R&D funding. Since there is a high demand for

engineers in the United Kingdom, these shortcomings support the conclusion that there is a lack of interest in engineering in the UK.

2.2 Engineering Outreach in the United Kingdom

In an effort to convince students to pursue engineering careers, researchers and organizations throughout the world have developed outreach programs designed to interest students in science, technology, engineering, and mathematics. Organizations in the United Kingdom have adopted these outreach methods to help increase the number of engineers in the nation.

2.2.1 Purpose of Engineering Outreach Programs

The specific purpose of each engineering outreach effort varies from program to program. Jeffers et al. (2006) summarized the goals of most engineering outreach programs by one or more of the following categories (Jeffers et al. 2006):

- Increasing engineering enrollment
- Diversifying the engineering field
- Educating the future generation
- Teaching the teacher
- Supporting the development of undergraduate students

However, a common link among all programs is the desire to increase primary and secondary school students' (or K-12 students in the United States) understanding of science, mathematics, and technology, and their interest in pursuing an engineering career (Poole et al. 1999). Given the current state of engineering in the United Kingdom, the focus of these programs should be to increase engineering enrollment in universities and educating the future generation about technology. Using outreach programs, education researchers have developed methods to address the issue of the declining number of engineering graduates in UK (see section 2.1.2, *The UK is*

Falling behind in Engineering). If students have a parent or a role model to expose them to the interesting aspects of science, math, and technology they are more likely to choose engineering as a profession (Abbitt et al. 1993). However, in many cases, the role of interesting students in STEM falls in the hands of teachers, who generally do not have the proper knowledge about the latest technological developments to accomplish this task. This means that some students capable of performing well in technical disciplines may never be exposed to those fields (Abbit et al. 1993). Organizers of outreach programs attempt to bridge this gap by acting as the outside influence that introduces students to technology and provokes an interest to pursue engineering.

Two popular methods used to implement outreach programs are hosting road shows at schools and conducting engineering contests. A road show consists of classroom demonstrations ranging from simple machines to advanced technology and equipment. Organizations generally use this method as an initial approach to outreach due to the simplicity of the programs (Jeffers et al. 2006). An outreach program involving an engineering contest can simply be sponsoring a local science fair by providing engineers as judges. On the other hand, outreach programs can also involve designing, organizing, and administering a project for students. One example is a program created by Hofstra University in Long Island, New York. To help increase middle school students' (11–14 year old students) interest in technology the University organized a project where students built and raced magnetically levitated motorized vehicles. As part of the contest students were required to submit a drawing of their vehicle and provide information on the mathematics and physics behind their design (Jeffers et al. 2006). Regardless of how simple or complex, these engineering outreach programs expose students to the excitement of science, math, and technology.

2.2.2 Evaluating and Understanding the Effectiveness of Outreach Programs

To provide an accurate analysis of the effectiveness of an outreach program, organizers must evaluate whether students' knowledge of engineering concepts and understanding of the role of an engineer increased after participation. Evaluating how a program changed participants' understanding, insight, and attitude towards engineering provides an adequate amount of data to quantify the effect of an outreach effort (Nadelson & Callahan, 2011).

To quantify the influence of outreach programs, two researchers from Boise State University (located in Boise, Idaho) assessed two engineering summer camps designed for students aged 14-19 called e-Camp and e-Girls. Both summer camps focused on increasing engineering awareness in hopes of convincing students to pursue a career in an engineering discipline (Nadelson & Callahan, 2011). To collect data, the researchers used a comprehensive survey to ask participants their opinions on engineering. The researchers adapted these questions from the "Pittsburgh Freshman Engineering Attitudes" survey developed by Besterfield-Sacre et al (1998), and simplified to suit a younger audience. The survey Nadelson and Callahan (2011) developed consisted of 29 questions with responses set on a scale from one to five (one being "strongly disagree" and five being "strongly agree"). As an example, the participants responded to questions similar to "Engineering would be a rewarding career" and "From what I know, engineering is boring" (Nadelson & Callahan, 2011). Table 2 provides the overall interest in engineering, determined from the average survey score of each participant, before and after each event.

Table 2. Pre and Post Survey Averages of 29 Questions on Attitudes Toward Engineering

Measure	Outreach Event	N	Pre-Test Mean(SD)	Post-Test Mean(SD)
Attitudes Toward Engineering	e-Camp	34	3.51(.26)	3.63(.24)
	e-Girls	38	3.47(.29)	3.83(.32)

Source: Data adapted from (Nadelson et al. 2011)

Between the two events, there was an average increase of 0.49 points (on a scale of one to five) in engineering interest amongst students, which is a statistically significant change (Nadelson & Callahan, 2011). This study provides quantitative evidence that outreach programs may have an effect on students. Additional researchers and organizations can adopt the methods from this study to provide an approach to evaluating interest in engineering, knowledge of engineering concepts, and understanding of engineering. In addition to solely evaluating programs, organizers must address findings from the analysis and consider these results while

designing future outreach efforts (Poole et al. 1999). Outreach program designers can improve existing programs by increasing focus on the stronger parts or improving on the weaker, less successful aspects of a program. Failing to incorporate a final program assessment in an engineering outreach program wastes the time, resources, and data collected as program designers are unable to use data from the analysis to improve the quality of future outreach efforts (Poole et al. 1999).

2.2.3 Organizations Promoting Engineering in the UK

Several British organizations have focused on providing engineering outreach programs to the youth of the United Kingdom in hopes to create future engineers. The two largest of these outreach organizations are EngineeringUK and Young Engineers, based in London. The mission statements of these organizations align with three of the goals described in Jeffers et al. (2006), which are to increase engineering enrollment in universities, diversify the engineering field, and educate the future generation on science and technology.

EngineeringUK is a non-profit organization that partners with the engineering community in the United Kingdom in an effort to expose students to the important role of engineers in society (EngineeringUK, n.d.a). The goal of this organization is to partner with engineering companies to shape future engineers for a successful career in industry. The organization's major outreach effort is known as the Tomorrow's Engineers program. The Tomorrow's Engineers outreach program includes in-school workshops with hands-on activities, visits to engineering companies to expose students to industry, mentorship programs, and engineering career fairs. In addition to traditional outreach methods, Tomorrow's Engineers also holds a social media campaign once a year as part of "Tomorrow's Engineers Week" that spreads their message to a broader audience (EngineeringUK, n.d.b).

The Tomorrow's Engineers program has successfully influenced youth in the UK. According to EngineeringUK, 50% of students involved with the program report that they understand what engineering jobs entail compared to 25% of students in a general UK sample. Tomorrow's Engineers has also influenced how primary and secondary school students view

pursuing an engineering career. In the general UK population 41% of students believed engineering is a worthwhile career, while 49% of Tomorrow's Engineers participants shared the same opinion (EngineeringUK, n.d.b).

Founded in 1983, Young Engineers is a non-profit organization that organizes a variety of hands-on activities designed to promote critical thinking and practical problem solving skills (Young Engineers, 2016a). As an engineering outreach effort, Young Engineers offers schools the option to host STEM Challenge Events. Competition coordinators give a small group of students a problem and challenge them to design and build a solution. Types of problems include creating practical robot designs, designing a hydro generator, and building a dragster race car (Young Engineers, 2016b). Throughout their 23 years of providing these STEM programs, the organization has worked with over one million students throughout the United Kingdom (Young Engineers, 2016a). These organizations are a resource for new outreach efforts. Due to their size and influence throughout London, looking to both Young Engineers and EngineeringUK for guidance and partnership can prove beneficial while designing an outreach program. Due to their success, these programs have set a reliable framework for other engineering outreach programs in the United Kingdom to follow.

2.3 Partnerships and Corporate Philanthropy

The successful formation of partnerships relies on three main factors: perceived need, willingness, and ability (Bazzoli et al., 1997). In order for an organization to become interested in a partnership it must have a perceived need for that partnership. Perceived needs could be anything from a shared goal to the need for additional financial resources (Bazzoli et al., 1997). The willingness of an organization to collaborate is based on the organization's net gain from collaboration. If the actions of the collaboration aim to accomplish something that is in line with the goals of the organization then it will be much more willing to collaborate than it would be otherwise (Bazzoli et al., 1997). When an organization is willing to collaborate it must have the ability to collaborate in order for a partnership to be formed. The ability of an organization to collaborate is based on factors such as available resources, skills, and the capabilities of the

organization (Bazzoli et al., 1997). Whether or not the organization wants to participate in a partnership does not change its ability to do so.

Once organizations form a partnership there are several characteristics that make it successful. Some of these characteristics are openness, mutual trust, clear objectives, and equality. If the partnered organizations are open with each other they will operate effectively by assessing each other's strengths and weaknesses. Having openness also helps the organizations avoid conflicts. Organizations that can trust each other make decisions more effectively. Without mutual trust, each organization will have to evaluate the motives of the other which will slow down decision making. When the organizations have clear objectives they can effectively focus their efforts and allow for better productivity and allocation of resources. Equality in decision making keeps both organizations interested in the partnership since they are both equally invested in the actions of the collaboration (Proulx et. al., 1999).

Charities must understand corporate philanthropy in order to gain funding from corporations. Corporations have specific motivations behind their philanthropic spending, as well as reasons for choosing which causes to support. Charities should understand two specific types of corporate motivation: strategic and managerial utility (Campbell et al., 2002). Companies' strategic motivations for philanthropy are based on company reputation. Companies with more philanthropic spending generally have a better reputation with their investors, consumers, employees, and other stakeholders. According to Brammer & Millington (2005) company reputation directly affects company value as well as employee retention and productivity. Companies also tend to relate their philanthropy to their business and their customer base to increase their gain in reputation even further. Companies' managerial utility motivations for philanthropy stem from the tendency of managers to invest in causes that interest them personally (Campbell et al., 2002).

2.4 The London Borough of Merton

The London Borough of Merton was formed in 1965 as the result of the municipal boroughs Mitcham, Morden, Merton, and Wimbledon merging. The boroughs have been rich in culture and trade since 43 CE, when Roman conquerors built a road and trade route linking London and Chichester (Merton Council, n.d.a). Since then, Merton has been occupied by Anglo-Saxons, Normans, and finally the English in 1114 CE. The industrial revolution brought about an explosion of manufacturing companies focused on milling. The rushing water of the River Wandle served as means for transportation and a power source for many milling operations. The usefulness of the Wandle's fast flowing water led to the construction of the Surrey Iron Railway, the world's first public railway, which in turn attracted wealthy Londoners and nobility to reside in Merton's growing suburbia (Merton Council, n.d.a). Disaster struck during World War II and Merton did not recover from damages until 1956, just nine years before the borough officially formed. Currently, Merton's five town centers provide entertainment, sports matches, and various shopping opportunities to its 200,000 residents. Merton's largest attraction is the famous All England Lawn Tennis Club in Wimbledon, where the annual Wimbledon Championships occur. The tournament nearly quadruples the population of Merton, drawing in upwards of 500,000 tennis fans and tourists (N. Martin, personal communication, 25 November 2015).

Merton's governing council is classified as a "unitary Authority," meaning it is responsible for all government functions in the borough. Such responsibilities include social services, libraries, waste collection and disposal, education, and much more. The council is exempt from managing emergency services such as road maintenance or public transportation, which is instead handled by the Mayor of London's departments (N. Martin, personal communication, 25 November 2015). When it comes to making decisions, the council is heavily influenced by its Labour Party members, which make up over two-thirds of its seats (Merton Council, n.d.b). Commonly referred to as "New Labour," the party is similar to the left-oriented United States Democratic Party, though New Labour holds much stronger ties to socialism.

2.4.1 Demographics

The Polish community, Merton's largest minority demographic, is located in the Pollards Hill neighborhood (London Borough of Merton, 2013). Pollards Hill is characterized by interwar housing, large green spaces, and community-shared areas such as outdoor gyms, tennis courts, a teen shelter, and several playgrounds. The neighborhood is split into three distinct areas: New Barns, Yorkshire Road, and Recreation Way. Each area has been assessed by the Borough on ten qualities it considers necessary for a successful community. Several notable qualities include significant landmarks or views, historical value, street layout, and architectural beauty. Each quality contributes to the area's total score, unless the quality in question is deemed "poor," which equates to zero contribution. The average rank for the entire neighborhood is sixty-five out of one-hundred, meaning Pollards Hill has much room for improvement, but is not queued for immediate changes to improve quality of life (London Borough of Merton, n.d.).

The London Borough of Merton (2013) predicts Pollards Hill will have a relatively large population increase of 4% in the upcoming year, which gives it slightly more priority for changes than other, wealthier wards. Pollards Hill is characterized by areas of low to mid income, unemployment, and deprivation, yet the borough's performance on the Early Years Foundation Stage Profile (EYFSP) is higher than the national average (London Borough of Merton, n.d.a.). The EYFSP is used to measure the performance of a child's personal, social, emotional, communication, language, literacy, and learning skills. The term "deprivation" refers to the Indices of Multiple Deprivation (IMD), which provide a means to analyze a borough or individual ward based on seven domains of deprivation (Gill, 2015):

1. Income
2. Employment
3. Education, Skills, and Training
4. Health and Disability
5. Crime
6. Barriers to Housing and Services
7. Living Environments

Figure 3 below shows a map of Merton's deprivation levels. The color red indicates an area of high deprivation while blue indicates an area of little deprivation.

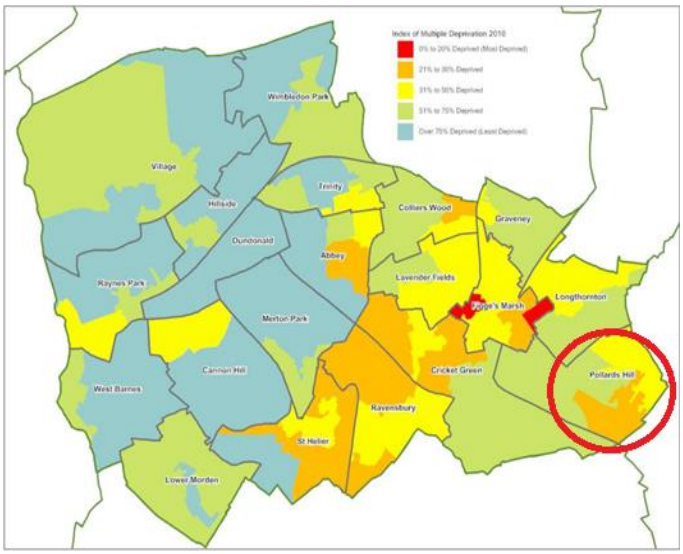

Figure 3. Map of deprivation levels within the Borough of Merton (2011)
Source: (London Borough of Merton, n.d)

From the map, East Merton and portions of Pollards Hill are significantly deprived and are likely to remain in such a state due to strict budgeting rules (London Borough of Merton, 2013). Although 20,000 people travel to and from Merton each year, net migration within Merton is almost neutral: fewer than 500 people remain within the borough during their travels. Most migrants originate within the UK; however, one third of the migrant population has overseas origins. The largest population in Merton is English and the second largest population is Polish (London Borough of Merton, 2013).

In comparison to England as a whole, Merton has a larger population of children aged 0-4, a much higher percent of adults aged 20-45, and a lower percent of adults within retirement age ("The Merton Story," 2011). Merton's high percent of a younger population and Pollards Hill's high levels of deprivation make the ward a good contender for a community initiative focused on education. See Figure 4 below for a visual comparison of Merton's age and gender demographic versus the average in England. The center graphic combines England's and Merton's age and gender demographic for easier comparisons.

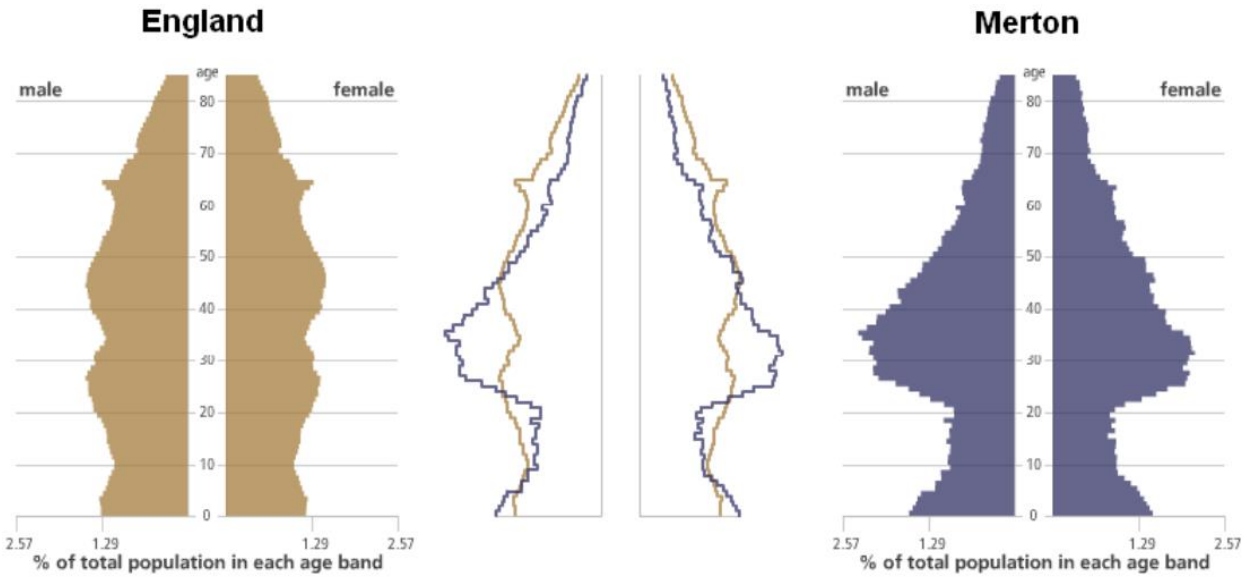

Figure 4. Age distributions by gender for populations of England and of Merton, (2011)

Source: ("The Merton Story,"2011)

2.5 About Commonside Community Development Trust

Commonside Community Development Trust is a charity organization based in Merton. Commonside is dedicated to improving the lives and environment of Merton residents through community development programs and community events, many of which are hosted at Commonside's New Horizon community centre. The Commonside mission statement, "to create a better future for ourselves, our families and our community," is the basis for all major decisions within the organization. Commonside's vision originally included a lengthy list of philanthropic goals, concepts, and ideas, but has since been refined and focused into a series of objectives with the help of another Interactive Qualifying Project (IQP) (Proulx et. al., 1999).

2.5.1 Commonside's Initiative

Commonside aims to create a powerful case for promoting engineering and technical skills and ensure Merton residents are the first pick for local engineering jobs. Engineering career paths are the least pursued in the UK. Only 64% of engineering graduates retain an engineering position and 11% of all college graduates work in an engineering field (Kumar et. al., 2015). Commonside's overarching goal is to have lawmakers, teachers, schools, and Merton's local community interested in engineering careers and education. Commonside hopes that the involvement of schools will help focus their current curriculum on science, technology, engineering, and math (STEM) subjects. Fortunately, over 90% of schools are comfortable with external organizations, such as Commonside, giving subject-specific career information to their students (Kumar et. al., 2015).

Commonside will also be focusing on incorporating Merton's rich history and culture into the initiative. Specifically, the Merton Historical Society, Wandle Industrial Museum, and Mitcham Common Conservators are likely candidates for partnerships to bring this goal to fruition. According to Naomi Martin, Commonside's director, local interest, cooperation, and participation should be greatly increased once we meet this goal.

3.0 Methodology

The goal of this project was to provide information and resources to help the Commonside Community Development Trust effectively implement a proposed initiative to promote engineering education in the local community. We developed the following objectives to achieve this goal:

1. To evaluate the current interest in and state of engineering education in east Merton.
2. To draft engineering outreach programs that incorporate the local history of the London Borough of Merton and the influential engineers who lived there.
3. To provide recommendations for engaging potential supporters and partners for the proposed initiative.

In this chapter, we cover the methods that we used to complete these objectives. Using the information we collected from these objectives Commonside will be able to justify their proposed initiative using relevant data, focus their outreach efforts on specific areas, understand how to create outreach programs that are unique to Merton, and form partnerships with potential supporters of the proposed initiative.

3.1 Objective #1

Our first objective was to evaluate the current interest in and state of engineering education in east Merton. To gain supporters Commonside must be able to justify the reason for creating an engineering outreach initiative to potential partners, schools, and the local council. We needed to collect data to determine whether east Merton students will benefit from additional engineering education. In addition to justifying the creation of the engineering outreach initiative, we also required data to determine which segments of the student population would

benefit most from engineering outreach programs. To accomplish this objective we created a survey for students aged 11 to 15 years old and conducted interviews with school teachers and administrators.

3.1.1 Student Survey

We created a survey for students aged 11 to 15 years old and distributed it to St. Mark's Church of England Academy in Mitcham as well as through programs hosted by Commonside. Our sponsor liaison determined which academies we should survey based on her existing contacts and their availability. In addition to contacting St. Mark's Academy, we also attempted to distribute the survey to two Harris Academies in Merton but, while the schools were interested in project, they were unfortunately unable to assist at this time. We decided to survey students aged 11 to 15 because at age 11 students move to their secondary education and by age 15 they have to select their options, or in other words students will be taking classes pertaining to a specific career path in which they have expressed an interest. We focused on this age group because outreach programs are likely to have a much greater effect on students considering their options than on students who have already decided on their remaining classes.

In the survey we asked questions that would help us determine how interested students were in engineering and how willing they were to learn more about the subject. We asked questions with a "strongly disagree" to "strongly agree" scale with both forward and reverse phrasing to help us identify outliers. We designed our survey to gather data on four key areas of interest. We wanted to know if age or gender correlated with interest in engineering to help us determine which groups of students Commonside's outreach programs should target. We wanted to know whether outside influence increased student interest in engineering to help us determine whether or not Commonside should focus on bettering the community's opinions of engineering. We wanted to know if students were interested in additional opportunities to learn about engineering so that we could help Commonside determine what kinds of programs to run in order to gain the most interest from students. Finally, we wanted to know whether performance in STEM correlated with an interest in engineering to help us determine if Commonside could build on existing STEM programs to help promote engineering. We could

use the information from these four points to determine the current interest level in engineering among students, the ages where Commonside should focus outreach efforts, and the ways additional engineering education will affect students. All this information will be used to help Commonside effectively implement the engineering outreach initiative. The final survey we provided is located in Appendix A.

3.1.2 Interviews with Teachers and Administrators

We conducted semi-structured interviews with local teachers and school administrators to determine their opinions of engineering education and the ability of schools to increase engineering education. We interviewed Vice Principals Austin Sheppard and Jonathan Harris as well as Max the IT coordinator from St. Mark's Church of England Academy. Vice Principal Sheppard is the former maths director and both Vice Principals are heavily involved in the integration of technology education into the school's curriculum. In these interviews we asked questions that would help us understand how teachers viewed engineering, how much focus was on engineering in school curricula and activities, and how willing schools were to incorporate engineering into after-school activities. We wanted to know this information so that we could evaluate the current state of engineering education within schools and use this information to determine how Commonside should approach the proposed initiative. The guideline document we used for our interviews with teachers is located in Appendix B.

3.2 Objective #2

Our second objective was to draft engineering outreach programs that incorporate the local history of the London Borough of Merton and the influential engineers that lived there. For Commonside to have an effective, widespread initiative, the organization must gain the support of the local governing council. The local council will be more likely to support a project that teaches participants about where they live and creates a sense of community identity (N. Martin, personal communication, 21 March 2016). By using our draft program outlines as the first step of development, Commonside will be able to provide engineering outreach programs that teach participants unique historical aspects about their home. To accomplish this objective we

interviewed local history experts, conducted additional independent research on industrial history utilizing local resources, and used this information to create outlines for potential outreach programs.

3.2.1 Interviews with History Experts

We conducted semi-structured interviews with experts at local historical societies to determine important aspects of local industrial history and to learn about historical resources and sites that may be useful to include in outreach programs. We interviewed volunteers from the Wandle Industrial Museum and Sarah Gould from the Merton Heritage Society. We chose these organizations because they have extensive knowledge and resources on local history, especially history about industry relevant to engineering. The protocols and guidelines used for these interviews appear in Appendix C of this report.

Our purpose in conducting these interviews was to learn about the resources each organization had available, the importance of local history to Merton residents, and the methods to utilize each organization to develop outreach programs designed to interest students in engineering. We asked each organization to describe how their resources could be used to develop after school programs for students, to discuss any existing outreach programs, to explain any historical or industrial sites of local importance, and to express how the industrial history of the area has affected local culture.

3.2.2 Independent Research

We conducted independent research to strengthen our understanding of local history and methods for designing engineering outreach programs. Prior to our interviews with local representatives from local historical societies we conducted preliminary research at the Morden Library. Our sponsor liaison recommended this location due to the library's large historical archives containing information on local history. Researching local industrial history allowed us to focus interview discussions on topics relevant to our project, rather than discussing the basic history of the area. After we completed interviews with local history experts we continued our

research at the Morden Library, utilizing the resources recommended to us during our interviews. Conducting additional research allowed us to explore the resources recommended by local history experts, to determine what information was relevant to Commonside's initiative, and to decide which resources would be helpful for designing engineering outreach programs.

Figure 5. Merton Civic Centre, location of the Morden Library
Source: (Local London, n.d.)

3.2.3 Developing Draft Outlines for Potential Outreach Programs

Using the information and resources from our interviews and independent research we developed ideas for possible programs as a means to incorporate local history into Commonside's engineering outreach initiative. Commonside did not request our team create finalized outreach program designs. However, we felt it was necessary to outline different types of outreach programs for teachers and extracurricular coordinators. To ensure organizers have a variety of programs to choose from, these outreach programs ranged from in-class demonstrations and experiments to class field trips. In addition, we ensured our programs met some or all of the engineering outreach program goals described by Jeffers et al. (2004) described in section 2.2.1 *Purpose of Engineering Outreach Programs*. With these programs we aim to achieve the following two outreach goals: to increase engineering enrollment and to educate students about technology and engineering.

For these draft outlines, we decided that each program would describe one or more local history subjects and incorporate a hands-on engineering demonstration or activity related to the aforementioned subject(s). To determine which local history subjects would be a suitable topic for an engineering outreach program, we asked a set of questions. For each of the topics we researched, we determined if this topic was related directly to technology or engineering, if we can design a hands-on program related to this topic that involves construction or design, if the level of material covered in the program is similar to the material covered in class for students aged 11-15 years old, and if a 11-15 year old student will find the material and program interesting. For each topic we answered the first two questions with a "yes" or "no" answer due to the straightforward nature of these questions. For the third question we used personal experiences from our time as middle school and high school students to determine which topics 11-15 year old students will understand. Similar to question three, we answered the final question using our personal experiences to determine what would interest a student aged 11 to 15 years old.

For each program we designed a three point outline. This outline provides a short description of the program, the information students should learn from the program, and the importance of what the students will learn. We designed this outline format to convey the purpose and outcome of each program to our sponsor. Alongside these three points, we also tried to anticipate potential problems that may arise when Commonside finalizes these programs allowing them to prepare for any issues during the planning phase of these outreach programs.

In addition to creating programs primarily for students we also outlined a program that involved parents. Allowing parents to join in the activity fits Commonside's goal of family education and inclusion. Including parents also allows adults to get exposed to engineering and hopefully encourage their son or daughter to pursue a career in engineering if their child shows an interest in the subject. These programs involved slightly more comprehensive or complex topics instead of the very simple and straightforward programs we designed purely for young students. Designing programs with moderately difficult tasks or with tasks that require adult supervision is an excellent method for compelling parents to become more involved in activities. Simple tasks such as using a hot-glue gun, cutting with a utility knife, or working through logic problems can be an exciting way to involve children and their guardians.

3.3 Objective #3

Our third objective was to provide recommendations for engaging potential supporters and partners for the proposed initiative. For a small to medium-sized charity like Commonside to implement a large-scale education initiative, the organization will require support, funding, and volunteers supplied through partnerships. Since private engineering companies will benefit most from an initiative designed to increase the number of future engineers, we focused on developing recommendations to partner with private sector companies. To accomplish this objective we developed partnership recommendations through discussion with individuals with experience forming partnerships in the community and by utilizing documentation created by Proulx et al. (1999). Once we determined these strategies, we interviewed local companies to discuss their interest in promoting engineering education and supporting Commonside's initiative.

3.3.1 Developing Partnership Recommendations

To develop our recommendations for initiating partnerships, we interviewed individuals in the community that were highly qualified or had experience with forming public and private sector partnerships. We discovered a previous IQP during our independent research in which the results section outlines the characteristics of a successful partnership in Merton, but do not detail the steps toward obtaining a partnership (Proulx et. al., 1999). To learn more about the steps of partnering, we discussed how charities could form local partnerships with Fitzroy Dawson, the CEO and founder of Merton Community Transport, a volunteer organization providing free transportation to disabled persons in Merton. We chose to speak with Mr. Dawson after attending his presentation at the 2016 Annual Voluntary Sector Conference. In his presentation, Mr. Dawson described his process of founding a community organization, working with local businesses and government bodies, and sustaining the organization with partnerships. We also interviewed Steve Farrow, a representative for the Training & Recruitment Partnership (TRP). Mr. Farrow is the general manager of the TRP and is the primary contact who interacts with the companies partnered with TRP. The TRP partners with local businesses to provide

apprenticeships to Merton residents and was highly recommended to us by our sponsor liaison on account of their skills in partnerships and nonprofit status.

3.3.2 Interviews with Local Companies and Organizations

We conducted semi-structured interviews with representatives from local businesses to determine their interest in promoting engineering through Commonside's initiative and forming a partnership. We interviewed representatives from businesses suggested by our sponsor liaison and employed a snowball method to approach more possible partners; we asked each interviewee to suggest an organization that may be interested in promoting engineering. We interviewed representatives from a total of two companies. We provide a list of the company names and representatives we interviewed in Table 4 below.

Our purpose for conducting these interviews was to determine what businesses seek to gain from a partnership. This information allowed us to produce a recommendation on approaching private businesses for Commonside. We discussed the benefits of a partnership with the interviewees and asked for any unique contributions they could make. Through discussion with our sponsor liaison, we determined several contributions these organizations could make: providing private funding, hosting enrichment (extra-curricular) activities, encouraging engineering through tours or innovative means, and attending career fairs.

Table 4: Businesses and organizations interviewed for partnerships

Company Name	Interviewee(s)	Interview Date
Root7	Rob Innes	15 April
Viridor	Paul Mabbett Garry Wolfe Robin Erskine Andrew Turner	27 April

To develop recommendations on partnering with private sector companies, we attempted to answer three important questions:

1. What criteria do companies have to meet in order to be considered for partnerships?
2. What makes a partnership worthwhile to the company?
3. What contributions from the company make the partnership worthwhile to Commonside?

We believe these questions cover some of the most important aspects of forming a partnership. By answering each in detail, Commonside will have all the necessary information to find companies that have a good chance of accepting a partnership proposal, explain to such companies what the benefits of a partnership are, and ultimately form a long-lasting partnership that benefits Commonside, the company, and the community through engineering outreach programs. The logistics of initiating a partnership are surprisingly uncomplicated, especially for a non-profit organization. Realistically, there will be no written contract that requires scrutinizing, just a verbal agreement. However, if Commonside or the company requests a contract, the two parties simply need to agree on expected results and an exit condition before drafting the contract.

4.0 Results and Analysis

During our time in London, we gathered data and created documentation which provides the Commonside Community Development Trust with information necessary to begin the development of their proposed community-wide engineering outreach initiative. The purpose of our data collection and following analyses was to provide justification for the creation of the proposed engineering outreach initiative, determine which demographics would be best suited for outreach programs, develop a way to incorporate local history and the accomplishments of influential engineers from Merton into the initiative, and create guidelines and recommendations that Commonside can use to initiate partnerships with local engineering companies. In this chapter we present our findings and discuss how we analyzed these data to create resources for Commonside.

4.1 Student and Teacher opinions on engineering education and Primary Demographics of Interest

Our first objective was to evaluate the interest in and state of engineering education in the east Merton area. As part of this objective we surveyed local students to determine their interest and opinions regarding engineering, maths, and science. We used this information to prove students would benefit from engineering outreach programs. We also interviewed teachers and administrators at St. Mark's Church of England Academy to determine faculty views on additional engineering education for students in addition to the school's willingness and ability to accommodate engineering oriented extracurricular activities. We determined that at this time students are interested in the engineering field but are not currently receiving enough education in this area. We also discovered that girls are less interested in engineering than boys. In addition, teachers and administrators at St. Mark's Academy agree that students would benefit from engineering oriented extracurricular activities and the school is willing and able to accommodate outside organizations running these programs. With these data we demonstrated that East Merton has both a need for additional engineering education and that schools and students will be receptive to these outreach efforts.

4.1.1 Results of Surveying Local Students

The following subsections provide the results from the survey given to 146 nine to nineteen year old students from St. Mark's Academy and at afterschool programs affiliated with Commonside. In this section, we also discuss the meaning of these results and how this information proves an engineering outreach initiative in east Merton will be beneficial for students.

4.1.1.1 *Student Career Interests and Aspirations*

We asked students to categorize twenty careers into four categories, ideal, expected, tolerable, and rejected. We defined ideal careers as the job the student would most like to do, expected careers as the job the student feels most likely to have after finishing education, tolerable careers as the job that the student would be willing to take, and rejected as the job the student absolutely will not do. Out of the students we surveyed 22.2% think of engineering as an ideal job. Nearly half of students responded that they considered engineering to be either an ideal or expected career. We represented the three most common non-STEM student aspirations next to three STEM subjects in Figure 6.

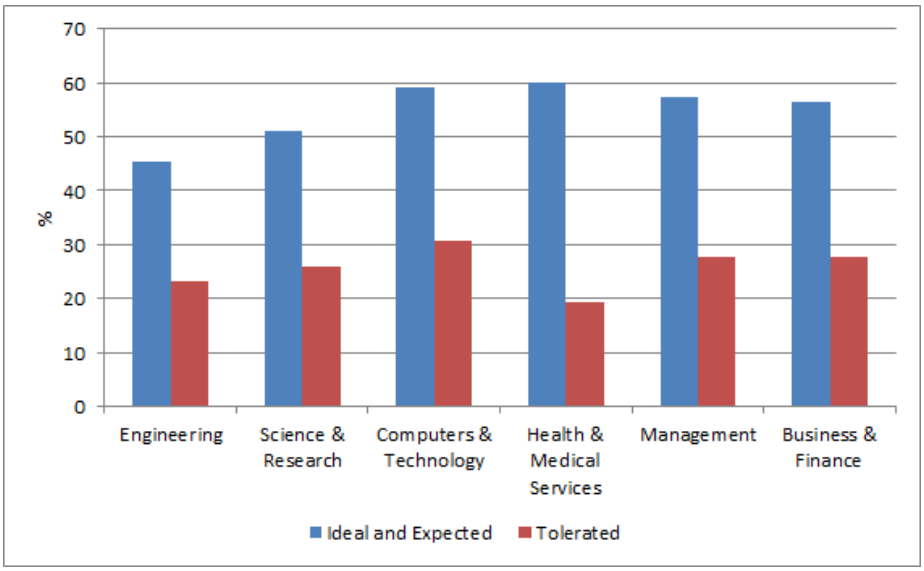

Figure 6. Student categorization of selected careers, sample size: 108

4.1.1.2 *Students are Interested in Learning More about Engineering*

Nearly 50% of students are interested in becoming engineers, as we mentioned in section 4.1.1.1 *Student Career Interests and Aspirations* and in Figure 6. In addition, an even higher percentage of students are interested in learning more about engineering. Out of the students we surveyed 57.6% responded that they would be interested in learning more about engineering, and 45.8% responded that they would be interested in participating in science or engineering after school activities. The percentage of students interested in learning more about engineering is much higher than the percentage of students who want to become engineers.

4.1.1.3 *Projects, Demonstrations, and Experiments Increase Student Interest in STEM Subjects*

We asked students three different questions in our survey to determine if experiments and demonstrations would increase their interest in STEM subjects. Out of the students we surveyed 87.4% agreed that if science had more experiments or demonstrations they would be more likely to enjoy the subject, 73.4% agreed that if maths classes had more projects or demonstrations they would be more likely to enjoy the subject, and 76.2% responded that they would be interested in engineering and technology related classroom experiments or demonstrations. We represented these data in Figure 7 below.

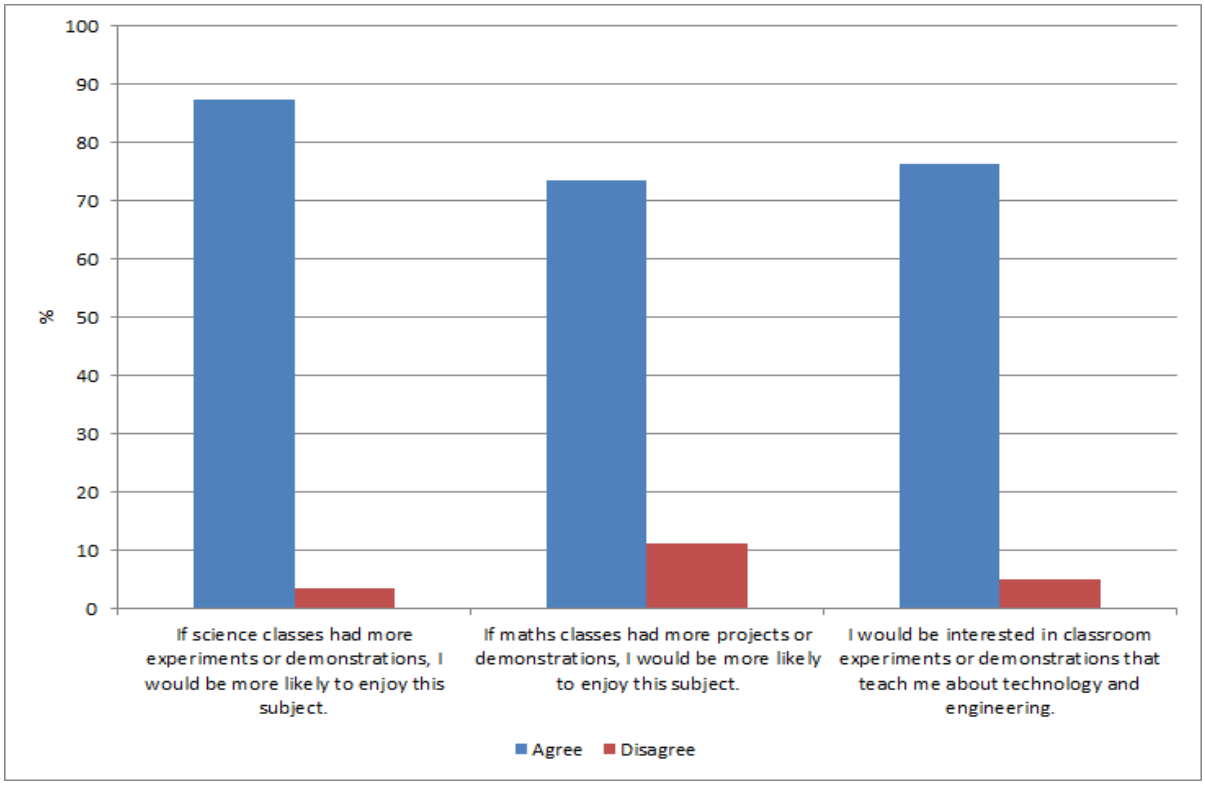

Figure 7. Reported student interest in projects, experiments, and demonstrations, sample size: 143

4.1.1.4 *Student Interest in Engineering Correlates with Gender but Not With Age*

Student interest in engineering does not have a positive or negative correlation with student age. However, student interest does still vary with age. Students aged twelve and fourteen reported less interest than other students between ages eleven and fifteen, which we show in Figure 8 below.

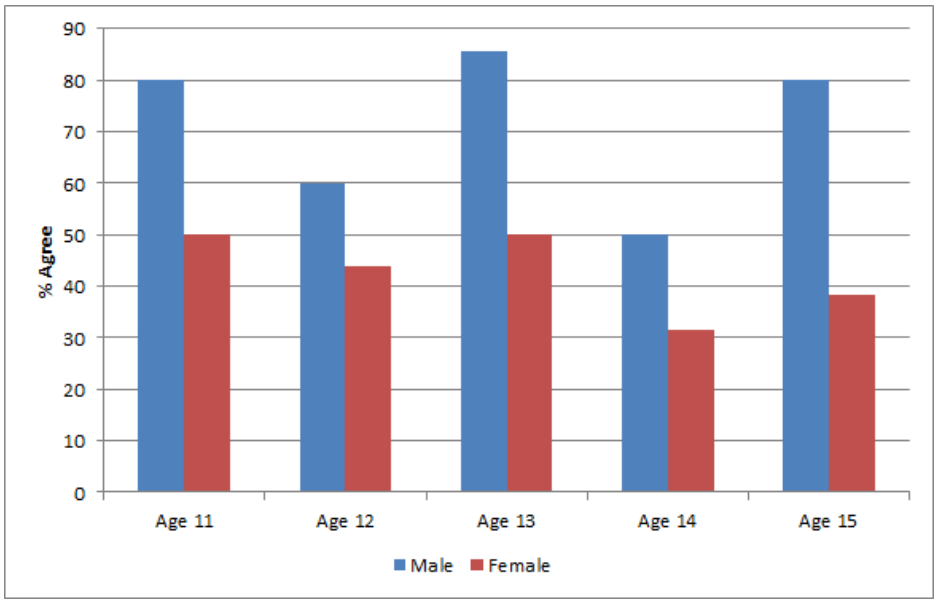

Figure 8. Student interest in learning more about engineering by age and gender, sample size: 122

We also found that male students were more interested in engineering as a career than female students. Of the male students we surveyed 59.6% placed engineering as either an ideal or expected career whereas only 20% of female students gave the same response. Male students reported more interest in learning more about engineering than female students as well, which we show in Figure 9. The percentage of female students who are interested in learning more about engineering is over double the percentage of female students who placed engineering either as an ideal or expected career. Additionally 54.4% of males and 38.2% of females responded that they would be interested in engineering-related after-school activities, which we also show in Figure 9 below.

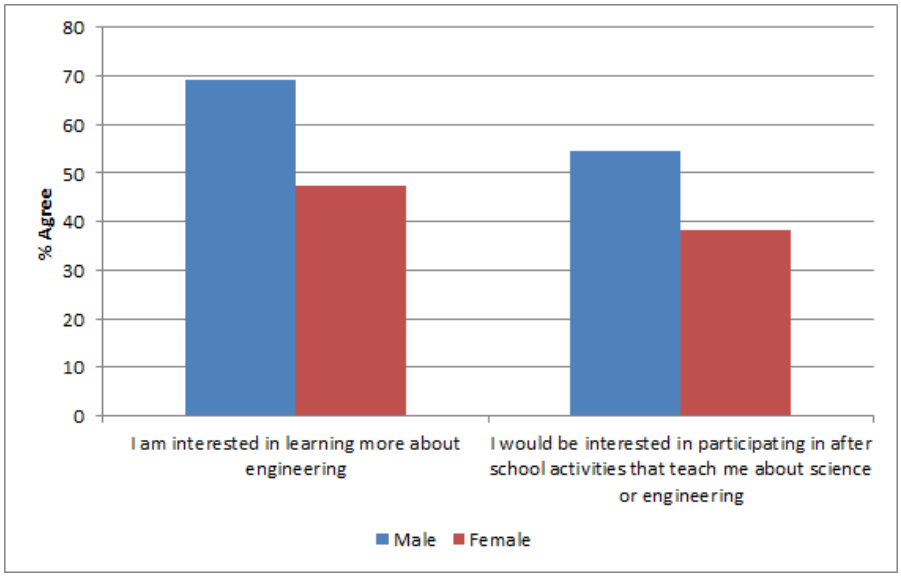

Figure 9. Interest in learning more about engineering and participating in engineering-related after-school activities by gender, sample size: 144

4.1.1.5 *Adult Influence and Exposure to Programs Affect Student Interest in Engineering*

Most students report that they have not been recommended engineering as a career by a parent, guardian, or other adult. Only 19.2% of students had adults recommend them engineering as a career, and only 26% of students had participated in an after-school science or engineering program. We represent these data in Figure 10 below.

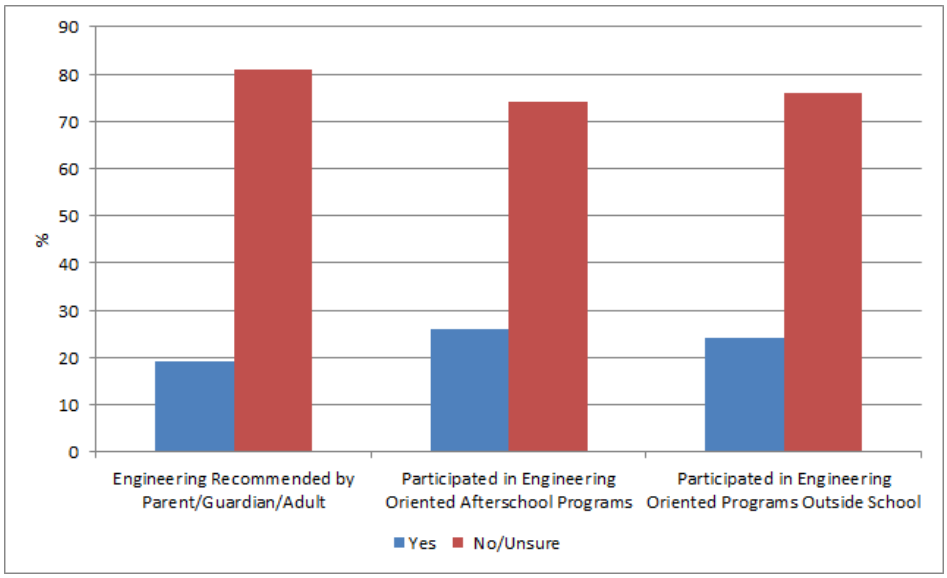

Figure 10. External engineering influence on students, sample size: 146

We discovered an adult recommendation can affect a student's view about engineering. A large majority of students who have discussed engineering with an adult believe engineering is an interesting career. Compared to students who had an adult recommendation, students who did not have adults recommend engineering are twice as likely to believe engineering is a boring career. We used a chi square test to determine that the difference in interest between the two groups is statistically significant, with p=0.0026. We represented the responses of students who had an adult recommend them a career in engineering next to the responses of students who did not have an adult recommend them an engineering career in Figure 11.

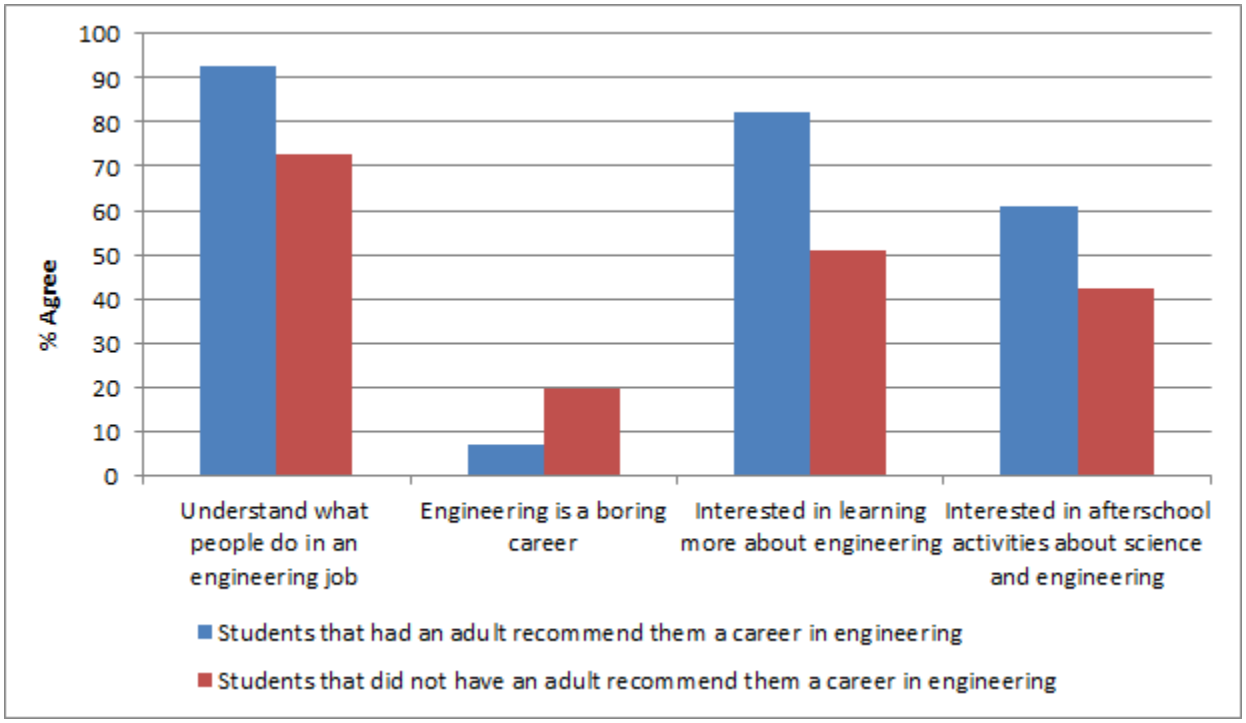

Figure 11. Interest in engineering when recommended by adults vs when not recommended by an adult, sample size: 146

Students who participated in after-school or out-of-school engineering programs showed more interest in learning more about engineering than students who had not participated in these programs. We used a chi square test to determine that the difference in interest between students who had participated in engineering-related after-school activities and students who had not is statistically significant, with p=0.0049. We represented these data in Figure 12 below.

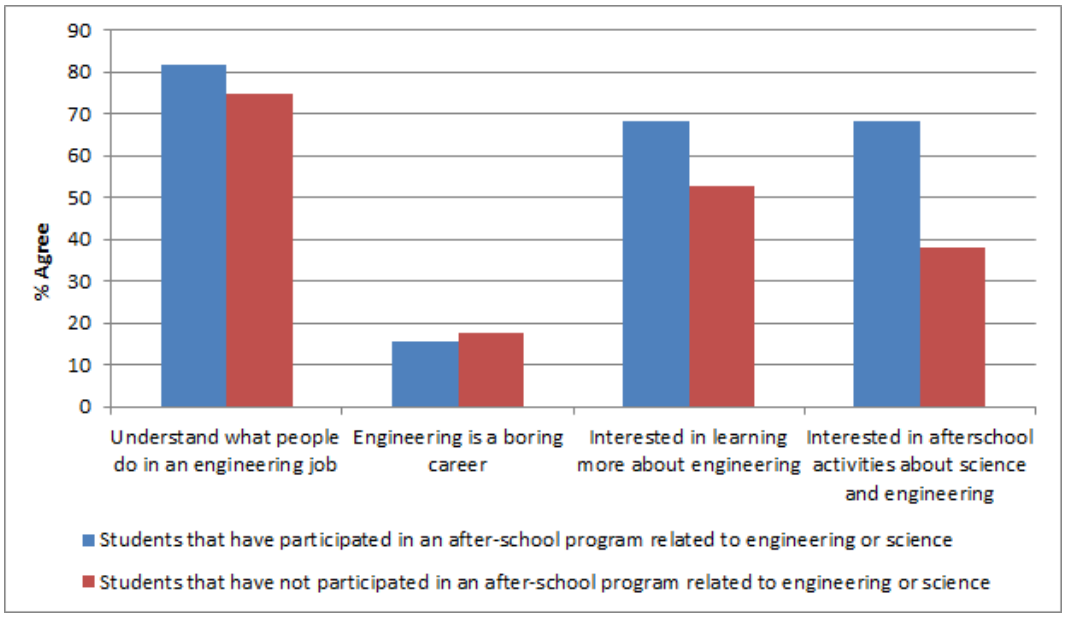

Figure 12. Interest in engineering of students that have participated in after-school engineering or science programs vs students that have not participated in after-school engineering or science programs, sample size: 146

We used a chi square test to determine that the difference in interest between students who had participated in engineering or science programs outside of school and students who had not is statistically significant, with p=0.0088. We represented these data in Figure 13 below.

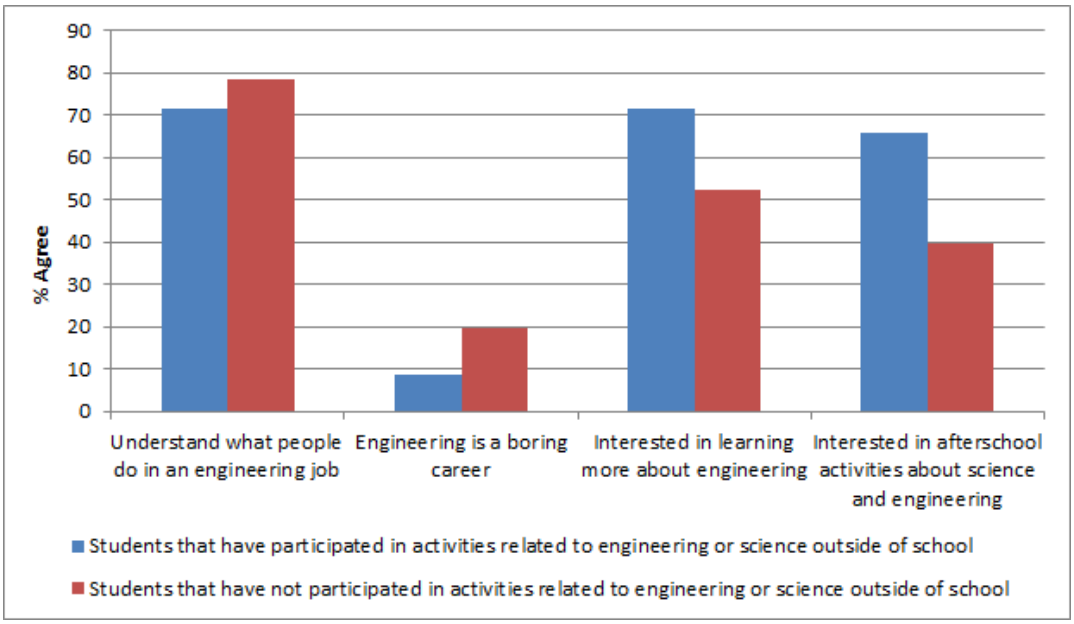

Figure 13. Interest in engineering of students that have participated in activities related to engineering or science outside of school vs students that have not participated in activities related to engineering or science outside of school, sample size: 146

4.1.1.6 *Student Performance in and Perception of Maths and Science is Not a Barrier to Increasing Interest in Engineering*

Out of the students we surveyed 52.05% reported that they were performing just as well or better in maths as their other subjects, and 36.99% reported that they were performing just as well or better in science than their other subjects. More students agreed than disagreed that maths and sciences are not boring, and most students believed that learning about maths and sciences is important. We represented these data in Figure 14 below.

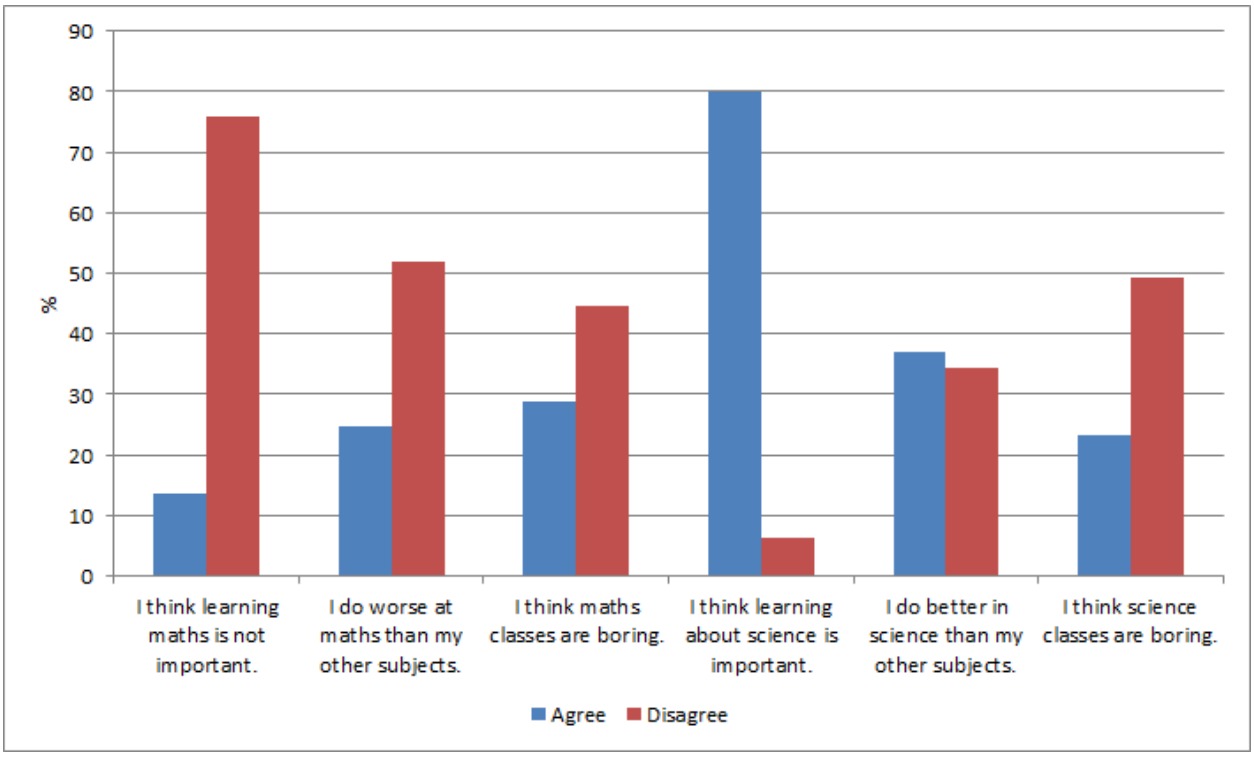

Figure 14. Student interest and performance in maths and science, sample size: 146

4.1.2 St. Mark's Church of England Academy Teachers and Administrators are Interested in Increasing the Amount of Engineering Education Students Receive

Teachers at the St. Mark's academy in Merton are interested in increasing the amount of engineering education that students receive. Vice Principal Austin Sheppard was enthusiastic about exposing students to engineering because he wanted to make sure that students are well informed when making decisions about their futures. According to Mr. Sheppard the administration at St. Mark's has already identified engineering and technology as a gap in the school's curriculum. Mr. Sheppard also stated that the school has a gap in enrichment opportunities involving engineering and technology. Mr. Sheppard would like to see more engineering education at St. Mark's and says that the students are "keen and eager" for it (A. Sheppard, personal communication, 26 April 2016). In addition, Vice Principal Jonathan Harris doesn't believe that St. Mark's prepares students well enough to pursue engineering degrees. Mr. Harris noted that while the school is adding product design to the curriculum in the 2016-2017 school year to help address the gap in the curriculum for technology, he believes that this addition to the curriculum will still not be enough to prepare students for upper level engineering universities.

Mr. Sheppard and Mr. Harris both expressed interest in providing students with more opportunities to learn about engineering and technology. Mr. Harris explained that the school will be facing reductions in available budget and that he would most likely lack the resources to add additional engineering enrichment programs for students. We asked Mr. Harris if he would be willing and able to accommodate outside organizations, such as Commonside, who wished to run these enrichment programs through the school and he said that he would "welcome it massively" as it will help with the costs associated with paying teachers or faculty to run these activities (J. Harris, personal communication, 26 April 2016). Mr. Sheppard was also enthusiastic about outside organizations running enrichment programs at the school and stated that they had success working with outside organizations in the past.

Mr. Sheppard mentioned some possible logistical issues that could arise when an outside organization runs an enrichment program in collaboration with the school. One major issue was transportation. Mr. Sheppard stated that he would prefer outside organizations host programs at the school to avoid this issue. Another major issue was security. Mr. Sheppard would have to

make sure the students are safe and that he could trust the outside organization. Mr. Sheppard said that no issues should arise that are insurmountable. The IT coordinator at St. Mark's said that the school's available technology could be an issue for outside organizations wishing to incorporate any technology into a program. He also recommended that any outside organization wishing to work with a school should get to know the individual school's resources and needs and adapt any programs accordingly rather than using a generic plan.

4.2 Outreach Programs Incorporating the Local History and Heritage of the London Borough of Merton

Our second objective was to determine a method for incorporating local history and heritage into Commonside's engineering outreach initiative. This objective consisted of three different steps. The first step of the objective was to interview representatives from local historical societies in Merton to determine the most useful resources, historical sites, and historical figures relating to industry and engineering in Merton. Once we completed this step, the second step to completing this objective was to continue research, narrow our focus, and decide which aspects of local industrial history we could use in a draft an outreach program designed to teach students local history as well as engineering skills. The third and final step of this objective was to design draft outreach programs for students. With the information we discovered, we outlined five outreach programs that expose students to aspects of engineering and technology while also teaching them about related local history.

4.2.1 STEP 1 - Discovering Local Resources, Historical Sites, and Historical Figures Relating to the Industrial History of Merton

We found that local historical societies in the Merton area had a plethora of information and insight into the industrial history of the borough. We interviewed Mick Taylor from the Wandle Industrial Museum and Sarah Gould from the Merton Heritage Society to learn more about local history and resources. Through these discussions we discovered that Merton has history related to industry, engineering, and technology.

Our first interview was with Mick Taylor from the Wandle Industrial Museum, a museum staffed by a group of volunteers focused on preserving the industrial history of the River Wandle running through Merton. Out of the several topics we discussed the three most relevant to technology, engineering, and east Merton where the River Wandle, Merton Abbey Mills, and printing mills. From the late 1700s to the 1950s the River Wandle was the hub for industry in Merton due to the fact that factories and mills could utilize the running water. Throughout the history of the borough, the River Wandle powered mills that produced dozens of different products including textiles, beer, iron, snuff, and gunpowder. Even today, when industrial activities no longer require water power, the area surrounding the river is still known as the center of Merton industry. The volunteers at the Wandle Industrial Museum stressed the importance of the Merton Abbey Mills and printing mills. Printing mills dominated the area of the River Wandle surrounding the east Merton area, so this industry has the greatest connection to the immediate area around Commonside. The volunteers also described Merton Abbey Mills, a former textile factory in east Merton, as one of the few remaining mills with a working waterwheel with most of the technology used for printing still operational and on display. In addition, this mill is open for tours and may be a useful addition to an outreach program.

Alongside discussing history, we also learned that the volunteers at the Wandle Industrial Museum already run a hands-on outreach program. This program teaches participants about the printing technology of the 18th/19th century mills along the River Wandle. As part of the program, students are given the chance to use this technology to make their own prints. This outreach program takes place in schools and while it is designed for younger students, the program is praised by the adults who participate in the activities. While the museum did not have a specific number on hand to provide us, Mick Taylor stated that the program receives a number of requests from local schools and that students are always eager to participate in the activities. The volunteers also mentioned that they are willing to incorporate their outreach program into Commonside's outreach initiative. Mick Taylor stated that if Commonside planned how to teach students about local printing mills and printing technology, the Museum would run their program alongside a more technical, engineering-specific program developed by Commonside. The complete transcription of the interview also appears in Appendix C.

Figure 15. Merton Abbey Mills water wheel
Source: (Linwood, 2008)

We also had an informal interview with Sarah Gould, the Heritage Officer of the Merton Heritage Society. Ms. Gould's job is to run the Merton history archives in the Morden Library. Alongside instructing us about how to utilize the library's vast resources, Ms. Gould also provided insight on influential engineers that were based in Merton, a topic the volunteers of the Wandle Industrial Museum did not specialize in. She described James Brunlees, a Scotland native and Merton resident who built several well-known railway bridges across England, Scotland, New Zealand, and even Brazil. Ms. Gould also described Joseph Bazalgette, a civil engineer who created the modern sewer system in London which ended the "Great Stink of London" created by a hot summer in 1848 and the cholera epidemics that plagued the city constantly. Both of these people were engineers who had a sizeable effect in not only the borough they lived, but London as a whole. Since this was an informal discussion there is no transcription of her interview included in the appendices.

4.2.2 STEP 2 - Determining Aspects of Local History Most Directly Related to Engineering Education

With the information and resources we gathered from our interviews with representatives from the Wandle Industrial Museum and the Merton Heritage Society, we determined which aspects of local industrial and engineering history were best suited to be the centerpiece of an engineering outreach program. While analyzing a piece of local industrial or engineering history to determine whether it was a suitable topic for an outreach program, we asked the following questions:

1. Does this topic have a direct relation to technology or engineering?
2. Can Commonside design a hands-on program related to construction or design with this topic?
3. Will this program be suitable for students aged 11-15 years old?
4. Will the students be interested by this topic and the program?

We provide more detailed information about how we formulated these questions in section 3.2.3 *Developing Draft Outlines for Potential Outreach Programs.* If a topic received a "Yes" for all four questions, then we deemed it a suitable topic for an outreach program. Through this analysis we determined four topics suitable for outreach programs, which are the water wheel in the Merton Abbey Mills, the textile printing techniques used at the Merton Abbey Mills, the railway bridges built by James Brunlees, and the London sewer system designed by Joseph Bazalgette. We provide a summary of our reasoning for choosing each topic in subsections 4.2.2.1, 4.2.2.2, 4.2.2.3, and 4.2.2.4.

4.2.2.1 *Suitable Topic #1: Merton Abbey Mills*

Merton Abbey Mills was a textile factory located in East Merton, which utilized the running water from the River Wandle to power its mills. In 1881 William Morris bought the mill and it converted from a silk factory to a textile printing mill. William Morris was a textile designer, poet, and novelist famous throughout England for his wallpaper, fabric, and stained glass designs. The factory operated as a textile printing mill from 1881 until the 1980s. While most of the mills that lined the River Wandle during the industrial era have either been destroyed or repurposed, Merton Abbey Mills is one of the only mills from the 19th century still in operation, providing visitors with a glimpse into the industrial era of London. While Merton Abbey Mills is no longer a printing mill, the preserved buildings house an artisan market. What makes Merton Abbey Mills unique compared to the other remaining mills along the River Wandle is the functional waterwheel which is still used to power the machinery inside the mill (M. Taylor, personal communication, 6 April 2016).

We determined that this topic is suitable for an engineering outreach program because we could confirm that this topic is directly related to engineering and that we could design a hands-on outreach program that would interest students aged 11 to 15 years old. The aspect of Merton Abbey Mills that relates to engineering is the operational water wheel. The water wheel is a simple machine that harnesses the energy of the moving river water and uses it to power all the equipment inside the mill. We can also design a hands-on activity involving the water wheel. Since the technology behind a waterwheel is very simple, we can have 11 to 15 year old students build their own miniature water wheel to demonstrate how the technology works. From our past experiences as middle and high school students (equivalent to primary and secondary school in the UK), we believe that students will enjoy an outreach program based on this topic because they will be able to see something they constructed perform an interesting and unique application. We provide a more thorough description of the outreach program we created based on the Merton Abbey Mills water wheel in section 4.2.3.1 of this chapter.

4.2.2.2 *Suitable Topic #2: James Brunlees and Railway Bridges*

While he was born in Scotland, Sir James Brunlees (1816-1892) was a well-known resident of Wimbledon, located in the Borough of Merton. Throughout his career as a civil engineer, Brunlees built several railway bridges in England, Scotland, New Zealand, and even a bridge in Brazil. His most important piece of work was the railway across the Morecambe Bay. He built this bridge to provide an essential link between the railways in Northern England to the railways in Southern England. While the total railway was only 19 miles, 10 of those miles were across embankments and tidal waters consisting of sand from 30 to 70 feet deep; this deep sand made the project very difficult. Despite this challenge, five years after Brunlees took over the role of construction engineer, he completed the bridge and the railway opened the line. His work on this bridge earned him praise from esteemed engineers and many others used his techniques to build bridges, viaducts, and piers (Grace's Guide, 2015).

We determined an outreach program related to engineer James Brunlees is suitable for students aged 11 to 15 years old. James Brunlees is related to engineering as he was a construction engineer for several companies and constructed bridges. Hands-on activities for our programs related to the railway bridges built by Brunlees are simple since students in our desired age group should have the skills to construct a simple model bridge. In grade school we performed similar bridge building tasks and the entire class responded positively to the activity, so we believe students participating in this program will react the same way. We provide more detailed descriptions on the outreach programs we drafted based on the works by James Brunlees in section 4.2.3.1 and 4.2.3.2 of this chapter.

4.2.2.3 *Suitable Topic #3: Joseph Bazalgette and the London Sewer System*

During the mid-19th century poor sewer systems and water treatment caused recurring deadly outbreaks of cholera. In 1854-1855 alone this disease killed over 10,000 Londoners. Alongside the constant cholera outbreaks, the hot summer of 1858 combined with poor water treatment caused a stench permeating from the River Thames so great that this smell became known as the "Great Stink of London". It was at this time that the chief engineer of London's metropolitan board of works and Merton resident, Joseph Bazalgette, was tasked by the city to redesign the antiquated sewer systems. His new sewer system intercepted the dirty water from old sewers and brought it down new low-level pipelines to updated treatment works. Alongside designing new pipelines, his plan involved major pumping stations and embankments on both sides of the River Thames. These pumping stations and embankments protected the sewers and underground railway while also reclaiming over 52 acres from the River Thames to use as roads and gardens. While designing the sewer, Bazalgette doubled all of his calculations for the diameters of the sewage pipelines to prepare for the 'unforeseen'. This foresight is a major reason why his sewage system is still in use today. By 1875, when Bazalgette completed the final pumping station, the new sewers had eliminated cholera outbreaks throughout the city. This sewer system designed by Joseph Bazalgette effectively saved tens of thousands of Londoners' lives (BBC History, 2014).

After our analysis of this topic, we determined that an outreach program based on the London sewer system designed by Merton resident and engineer Joseph Bazalgette is suitable for an outreach program for students aged 11 to 15 years old. We also decided that a hands-on activity or demonstration about water filtration and fluid flow would be appropriate for students since a teacher or program proctor can explain the basic fundamentals of fluid flow and discuss how Bazalgette used these concepts to design the sewer system. While fluid analysis can become quite complex, the concept of increasing area to increase fluid flow is simple to explain and a topic 11 to 15 year old students can understand. Part of this program may also include field trips for the participants. Students can tour the decorative pump stations designed by Bazalgette and observe how this machinery pumps and filters sewer water. By providing a visual experience in addition to demonstrations on the fundamental concepts behind fluid flow, we believe that

students will be engaged and interested in the program. We provide a more thorough description of the outreach program we created based on the sewer system designed by Joseph Bazalgette in section 4.2.3.4 of this chapter.

4.2.2.4 *SuitableTopic #4: Textile Printing Mill Technology*

During the British industrial era in the 19th century, the mills in the east Merton area were known for their textile printing factories. In 1881 famous textile designer William Morris bought Merton Abbey Mills and converted it from a silk factory into a textile printing mill. Textile designing in this era was considered artisan work; designers required several years of training and apprenticeships before they were proficient in this craft. Textile print designers would hand carve a design into a printing block (similar to a stamp), carefully add individual colors of dye, and essentially stamp the design into textile (M. Taylor, personal communication, 6 April 2016).

While there is little technology or traditional engineering involved in the creation of textile prints, we determined this is a suitable science, technology, engineering, arts, and maths (STEAM) topic. A program relating to 19th century textile printing techniques will help students learn about the arts and creative design side of product development. The Wandle Industrial Museum already offers a program in which students design a printing block and create a print on a piece of fabric. The volunteers at the museum are open to providing this service in a Commonside-sponsored program and can provide the required knowledge and expertise about textile printing. In addition, the volunteers mentioned that past participants have provided positive feedback about this activity, so an outreach program focused on textile printing should have similar feedback.

4.2.3 STEP 3 - Creating Draft Outreach Programs Designed to Teach Students about Technology, Engineering, and the History of Merton

Once we determined and researched the subjects for our proposed engineering outreach programs, the final step of our objective was to create drafts for these suggested programs. Using the subject areas we determined from our analysis in step two we developed a total of five programs designed for instructors to run either in school or during after school programs. We also designed one program that can include the student's parent(s) in the activity. For each of the subject areas listed in sections 4.2.2.1, 4.2.2.2, 4.2.2.3, and 4.2.2.4 we developed at least one outreach program with the purpose of teaching students about local history and exposing them to the technology and engineering concepts associated with this history subject.

For each program idea we created a draft covering three main points. With these points we state the topics the program will cover, the purpose of the program, and the outcome of the program. These three main points, detailed in section 3.2.3, are:

1. The description of the program
2. The information students should learn from the program
3. The importance of the information students will learn

A description of each program we drafted appears in the following five subsections. In our program outlines, we also noted any potential problems that may arise when Commonside finalizes these programs. A formatted draft for every program appears in Appendix I.

4.2.3.1 *Fundamentals of Water Power: Program Design*

This program incorporates the history of the Merton Abbey Mills along the River Wandle. Using the waterwheel in the historical Merton Abbey Mills as a tool, the purpose of this program is to teach students the basics about the water power used to power the mills along the river. This program contains two parts; in the first part of this program students will construct a simple miniature water wheel using balsa wood and cardboard. To demonstrate how this wheel generates power, students will place their wheel in a channel of flowing water, use the spinning motion of the wheel to power a small hand-crank generator, and use the electricity from the generator to power a lightbulb. In the second part of the program, students will see a water wheel in a real-life application. Utilizing the outreach program conducted by the volunteers from the Wandle Industrial Museum, students will tour the Merton Abbey Mills and learn how the water wheel provides power for the machinery in the mill. A teacher or an after school program advisor can proctor this program.

During this program students will learn how to relate mechanical work to electrical power. In addition, during the Merton Abbey Mills tour by the Wandle Industrial Museum volunteers students will learn how the material they learned during the program relates to an actual application. By visiting the mills and touring the water wheel, students can see how running water powers all the machines in the mill. Learning this information is important to students because every day students witness the benefits of the conversion of mechanical energy to electrical energy and vice versa, but may not understand the technology. By exposing students to this topic during the program, students will start to recognize the relationship between mechanical and electrical energy throughout everyday life. This relationship will help students begin to understand much of the appliances and technology they see every day. Exposing students to applications of the technology and concepts they learn is essential to solidifying their understanding of the topics. In most classes, students may learn maths, science, or simple technology but rarely get a chance to see these concepts in practical applications. If students learn the concepts but not the applications, they may believe these concepts are not important and forget about them. A formatted outline of this program appears in Section 1 of Appendix I.

4.2.3.2 *Railway Bridge Design Contest: Program Description*

This program incorporates the railway bridge designs built by James Brunlees. During this competitive program, students will design, build, and test a railway truss bridge similar to the bridges created by James Brunlees. Prior to beginning the program students will learn about James Brunlees, his work, and about the basics of designing a truss bridge. Before starting the competition, the program proctor will provide each participant with a set amount of "Pounds" which participants will use to "buy" materials such as glue, straws, spaghetti, tape, etc. to build their bridge. We provide a list of materials and suggested prices on the outline in Section 2 of Appendix I. Students will compete to decide which bridge holds the most total weight before breaking and which bridge has the highest weight supported to cost ratio. As a way to involve parents in the program the proctor may make the contest either parents versus students or have student-parent teams compete against each other. A teacher or an after school program advisor organizer can proctor this program.

In this program students will learn the basics of creative design and resource management. By incorporating a competition into a bridge building program, participants not only learn about how to construct a bridge, they will also think critically about optimizing their design. Participants are not trying just to construct a bridge; they are trying to construct the best bridge, so they must determine the best way to approach their design and the appropriate methods for the construction of their bridge. By adding the aspect of providing currency to participants, students will learn how to construct their bridge with minimal materials and how to determine which material is best for each application. Teaching this information to students is important because creative design is a very important part of the engineering field, as part of the engineer's job description is to innovate new ways to accomplish tasks in their respective fields. In a more general sense, creative design also encourages students to think of innovative solutions when approaching a problem. These skills will help students create innovative solutions to a variety of problems in a variety of jobs. In the business world projects have limitations and budgets. Once students enter the workforce they will have to consider cost in nearly everything they do. By teaching students how to factor cost into their designs, they will be prepared to work effectively under budget constraints. A formatted outline of this program appears in Section 2 of Appendix I.

4.2.3.3 *Railway Bridge Design, Construction and Testing: Program Description*

This program incorporates the railway bridge designs built by James Brunlees during his lifetime. In this program, students will learn about the engineering design process and use this knowledge to design, construct, and test a balsa wood bridge. Prior to the construction, the program proctor will provide a presentation outlining the physics behind truss bridges and the design process the students will use to create their own. Using the designs of the railway bridges built by James Brunlees as a reference, students will design each portion of the balsa wood bridge to scale on engineering paper. Using their bridge designs as a template, students will use balsa wood and hot glue to construct each individual section of their bridge. Once students complete each section, they will carefully glue their bridge together and test if their bridge is able to hold a minimum weight without breaking. During this process students will observe and record the locations where stress or damage occurs. If the participant's bridge holds the minimum weight, he or she can decide whether to continue testing and see the maximum weight the bridge can hold or to take it home as a memento. Due to the complexity and length of the program, proctors should conduct this program over two or three sessions of about an hour.

This bridge design program will teach participants about the engineering design process. Students who participate in the program will learn the basics about the methods engineers use to design, build, and test a model. After the first portion of the program, students will understand the basics of how engineers plan and draft their projects before the physical construction; they will be able to draw out a complete to-scale design. In the second portion of the program, students will learn how to construct individual sections and then configure a structure based on design documents. Finally, students will learn the correct approach about how to test a prototype model; they will learn how to observe and record the weight and location of structural damage on their bridge. Teaching this information to students is important because possessing a firm understanding of the engineering design process is an essential component of engineering. While secondary school students may learn important science and maths concepts related to engineering, few learn about the process behind the design and development of a product. Learning this skill in secondary school will benefit students looking to pursue an engineering degree at a university, as they will already understand good engineering practices. In addition,

learning the correct methods about how to design and build a product is not only useful to students looking to pursue engineering. Students can apply these skills to any project; understanding this process may help students build furniture, make repairs around the house, or assist with a hobby. A formatted outline of this program appears in Section 3 of Appendix I.

4.2.3.4 *Fluid flow and the Basics of Water Filtration: Program Description*

During this program participants will learn about the Merton resident Joseph Bazalgette, the importance of the London sewer system which he designed, and the fundamental fluid dynamics concepts he employed in his design. Before the students engage in the activities, the program proctor will introduce Joseph Bazalgette, note the deplorable conditions of the water in London during the mid-1800s, and mention how Bazalgette's new system cleaned the water in the city, ending the cholera epidemics and saving tens of thousands of lives. After the history lesson, participants will take part in two activities. The first activity is a hands-on demonstration of water filtration and fluid dynamics. With the help of volunteers, participants will construct two separate 'sewage pipes' out of plastic tubing. One 'sewer' system will contain tubing with a small diameter and the second will contain tubing with a much larger diameter. In addition to the tubing, each system will incorporate two types of filters. The first filter will sift out large objects, like dirt and mud, from water. A simple coffee filter should work for large particle filtration. The second filter is designed to filter smaller particles, like food coloring, from water. Micro-particle filtration requires a different filter; participants or a program proctor can construct an acceptable filter by poking holes in the bottom of a soda bottle, adding layers of cotton balls, and adding sand on top. Alternatively, the program proctor may also use a filter from a sports water bottle, if available. Once participants complete the construction the program proctor should pour a mixture of water, dirt, and food coloring into each pipe system. Students should observe the differences in fluid velocity and filtration quality between each 'sewer' system. After the demonstration the proctor will discuss how filters block particles and formally explain the relationship between fluid velocity and area. This explanation will segway into a discussion about how Bazalgette doubled the diameters of all his pipes to prevent water from flowing too fast through them and is why his sewer system is still in use today. The second part of the program consists of another activity and a field trip. In addition to pipelines, Bazalgette also

designed updated pump stations as part of his sewer system. Participants will use small motors, soda bottle caps, foam board, and straws to make a small water pump. Once participants build and test their small pumps they will travel to the Crossness Pump Station built by Bazalgette to see a piece of his work firsthand.

During the first part of the activity students will not only learn the basics of fluid dynamics, they will learn how Joseph Bazalgette used these concepts to engineer a sewer system that saved tens of thousands of lives. From the water pump activity and subsequent field trip participants will learn how the material they learned during the program relates to real life applications. This material is important because students may understand that engineering consists of using math and science to solve problems or innovate new technology, but few may understand the importance of this work and the effects engineering has on society. Understanding the widespread effect Joseph Bazalgette's work had on London will show students the importance of engineering and possibly inspire them to pursue a career in this field in hopes to one day to help the city like Bazalgette. A formatted outline of this program appears in Section 4 of Appendix I.

4.2.3.5 *Textile Printing in the Old Merton Abbey Mills: Program Description*

In this program participants will learn about the textile printing techniques used in the 18th and 19th century textile mills along the River Wandle, including Merton Abbey Mills. With the assistance of volunteers from the Wandle Industrial Museum, participants will design their own printing blocks, mix their own dyes, and create a textile print on a piece of fabric. While the prints are drying, students will learn about the job of a textile designer and the years of training these designers required to join this occupation. As part of this explanation, the Wandle Industrial Museum volunteers will provide students with examples of advanced textile designs and explain how textile workers employed the same printing techniques as the participants to create these more complex designs.

While this program is not specifically related to engineering, it teaches students about the creative design process behind product production. This program aligns with the goal of science, technology, engineering, arts, and maths, or STEAM, which is to incorporate design and creative

thinking into programs relating to technology or engineering. In addition to learning skills related to creative design, participants will also learn to recognize how basic and introductory techniques incorporate into advanced or complex designs. Teaching this information is important to students because boosting creativity through hands-on design will help students think of creative and innovative solutions when approaching a problem. Even though students may have a firm understanding of the science and construction methods required to solve a design problem, they may lack the creativity required to come up with an innovative solution. While not engineering design specific, creating a unique printing block will encourage students to think creatively about their designs. By providing students with explanations about how the basic techniques they learned are applied in complex textile print designs, they will learn how to apply the skills they learned to different and more advanced applications. By explaining to students that what they learned is not an isolated skill, but rather part of a bigger application, they may apply similar forms of thinking in other subjects and become more receptive to understanding advanced topics. A formatted outline of this program appears in Section 5 of Appendix I.

4.3 Private-Public Sector Partnership Strategies and Characteristics of a Mutually Beneficial Partnership

Our third objective was to develop recommendations for engaging potential supporters and partners to assist with Commonside's engineering outreach initiative. We interviewed Steve Farrow from the Training and Recruitment Partnership (TRP) and Fitzroy Dawson from Merton Community Transport (MCT) to determine the characteristics of a successful public-private sector partnership in Merton. We then interviewed representatives from Root7 and Viridor to determine what interest engineering companies would have in providing engineering outreach to the community, what each company can provide to support an outreach initiative, and what benefits each company would like to see from their involvement in engineering outreach programs. We determined that a nonprofit or charity organization should set up a meeting with expectations of both parties prepared in advance to have the best chance of initiating a successful partnership.

4.3.1 Insights on Private Sector - Non Profit Partnerships

From our interviews with Steve Farrow and Fitzroy Dawson, we determined several concepts we believe are extremely helpful for a non-profit organization to initiate a partnership. According to Mr. Farrow, word of mouth communication and working closely with local authorities, such as the Chamber of Commerce, is often the best way to discover companies and make connections with the appropriate contacts. Mr. Farrow suggested Commonside make themselves more known in the community, specifically what they stand for, what their aims are, and who they represent. Making these qualities known to the public is a task for a social media expert or individual with web development experience, since Commonside already has an official website. However, keeping a profile in the social media spheres requires constant maintenance and may be unnecessary when networking via verbal communication attains similar results. A full transcript of this interview appears in Appendix D.

In our interview with Mr. Dawson, we confirmed the importance of word of mouth communication. He noted that MCT has grown significantly since its inception primarily through face-to-face communication, rather than public advertising. In fact, Mr. Dawson suggested Commonside target high-profile companies and individuals when searching for potential partners or volunteers. His suggestion is based on personal experience of speaking with CEOs, millionaires, and successful entrepreneurs he believed were too distant to approach. Mr. Dawson refers to the networking tactic he used to connect with these individuals as “going to the path” (F. Dawson, personal communication, 22 April 2016). First he sets a specific goal; for example, “meeting with the CEO of Microsoft” is both specific and a long-term goal. Then he researches the individual to find all forms of communication common to both of you. Research methods may vary depending on the person you are trying to connect with. Some forms of communication may be through clubs, employees or coworkers, hobbies, business interests, and social media platforms such as LinkedIn, Facebook, Twitter, and so on. Mr. Dawson’s reason for targeting such individuals is that the most successful people are very often the most philanthropic and willing to help. We provide a transcript of this interview in Appendix E.

4.3.2 Interests of Private Sector Engineering Companies on Non-profit Partnerships

After interviewing Robert Innes from Root7 and several representatives from Viridor we determined the top four outcomes or benefits engineering companies are interested in obtaining as the result of a partnership with a non-profit organization:

1. Networking opportunities
2. Potential employees
3. Increased social profile
4. Tax deductibles from donations

With the knowledge of these benefits and information gathered from MCT, TRP, Root7, and Viridor we formed several recommendations that Commonside could use in providing examples and marketing themselves to private sector companies. Our suggestions appear in section 5.4, *Recommendations Regarding Partnerships*.

4.3.2.1 *Analyses of Engineering Company Interviews*

Our first interview was with Rob Innes, the director of Root7. The organization is made up of The Water Delivery Company, Root7, and Man and Van. The banner name "Root7" refers to all three companies which supply water coolers, kitchenware, and provide distribution services, respectively. Mr. Innes has been the director of Root7 for over twelve years. During our interview, we asked the following questions to learn more about the company and their views on engineering within Merton.

1. Would you say that Root7 currently needs more engineers or technicians?
2. What steps has Root7 taken to change this? (*in reference to the previous question*)
3. What do you think about the engineering community within Merton?
4. What kind of relationship does Root7 have with the local community?
5. Do you have an outreach program, or sponsor a sport team, or do something that lets the community recognize Root7?

In response to the first question, Mr. Innes simply stated without hesitation, "Yes." We inquired about any steps Root7 has taken to resolve this and Mr. Innes noted he recently hired a manufacturing design engineer. He told us Root7 is looking to manufacture its own products, starting with household beverage products, but it is quite difficult to find engineers in Merton. Our discussion naturally led to question three, in which Mr. Innes stated, "I can't say I see too much of it" (R. Innes, personal communication, 15 April 2016). Upon learning of our project work with Commonside, he suggested broadening our scope from just Merton to include the entirety of the UK or even other European countries. In relation to questions four and five, Mr. Innes said Root7 dabbles in community outreach, but currently does not have the time or resources to fully dedicate themselves to the matter. He is very interested in the outcome of the project and fully recognizes the deficiency of Engineering in the UK. We then asked another set of questions in a more discussion-friendly manner, rather than in the form of an interview.

1. How do you think Root7 can benefit this project?
2. How do you think Commonside can benefit Root7?
3. Has your organization partnered or considered a partnership with a charity organization before?

When inquired on how Root7 could contribute to Commonside's initiative, Mr Innes said Root7 could show youths the business aspect of engineering and manufacturing and possibly take on apprenticeships as the company grows. Mr. Innes also stated that word of mouth or email communication is the easiest and most direct method to connect with them. On question two, Mr. Innes stated networking and community recognition of Root7 are the most important benefits the company could receive from a charity. Finally, Root7 has worked with Commonside in the past, but has not entered any kind of formal partnership agreement. Mr. Innes stated he "buys into the

value of community outreach" and that Root7 does "bits and bobs" of charity work. We provide a transcript of this interview in Appendix F of this report.

Our second interview was with several representatives from Viridor: Paul Mabbett, Garry Wolfe, Robin Erskine, and Andrew Turner. Viridor is the largest waste management company in Europe and is currently undertaking a large-scale construction operation in Merton. Dubbed "the Incinerator" by locals, Viridor designed the waste management and energy production plant to receive over a hundred thousand kilograms of compostable waste from the surrounding area, incinerate the material into ashes, and produce electricity through steam turbines. The facility has received major pushback since the contract was won, even though it has fewer emissions than a personal fireplace, is self-sustaining, and will produce over 25MJ of energy every day. The site is located on a "green belt" land, or a protected green space where construction is usually restricted. The facility will only take up a small portion of the land which Garry Wolfe, civil engineer and project manager, argues is "the only logical place" for it.

Our discussion covered topics of engineering within the UK, engineering education, and community involvement. The four interviewees came to a consensus that Viridor always has a need for engineers to design, research, and oversee construction projects. Mr. Wolfe believes the cause of the engineering degree shortage in the UK is "too much variety" of attainable degrees and not enough push for the sciences. What he means by this is there are more degrees available to youths now compared to degrees available when he went to university. He believes there is also less of a push from the media and authority figures for students to go into the sciences. Fortunately, Viridor has a large apprenticeship program that focuses on 18 to 21 year old engineering graduates. Viridor attempts to support the local community in multiple ways and has £250,000 reserved for community restoration projects. Mr. Turner mentioned two previous projects: repairing the roof of a church and building a locker room for a public football field. Viridor also employs locally if possible and hosts community liaison meetings in which local leaders can voice their opinions, raise issues, and propose projects. In addition to Viridor's multitude of community outreach programs, the facility will have an educational center and on-site expert dedicated to giving tours and teaching students and adults about the incinerator.

After discussing Viridor's community involvement and views on engineering, we approached the topic of partnerships. Mr. Turner was very receptive to the idea and suggested

Commonside follow-up on the matter. We continued the discussion which produced results in line with our previous interviews and discussions. Commonside would provide the networking potential, possible apprenticeships, and in this scenario, students for Viridor's educational center and tours. Viridor would provide funding and volunteers for Commonside's engineering education initiative. While Viridor did not consent to a recorded interview, we provided our notes in Appendix G.

5.0 Conclusions and Recommendations

After reviewing the analysis of our interviews, research, and student survey we were able to provide Naomi Martin, Director of the Commonside Community Development Trust, with specific recommendations about how to approach the development of a community wide engineering outreach initiative. We split these recommendations into three categories: recommendations regarding schools and students, recommendations regarding outreach programs and local history, and recommendations regarding partnerships. In the following sections, we detail and justify each recommendation.

5.1 Conclusions

Using the survey data that we gathered, primarily from students aged eleven to fifteen at St. Mark's Academy in Mitcham in addition to nine students participating in afterschool programs affiliated with Commonside, we have evidence that students in east Merton would benefit from an engineering outreach initiative. Although the engineering sector in the United Kingdom is struggling to fill vacant positions with qualified engineers, most students would rather pursue careers in health and medical services, business and finance, and management. While there are nationwide charity organizations in the United Kingdom that provide students with engineering outreach programs, we determined that most students at St. Mark's Academy in east Merton had never experienced one of these programs and had not discussed the possibility of an engineering career with a parent, guardian, or other adult. Despite learning that only a small portion of students understand the role of an engineer and plan to pursue this career path, we discovered that a significant number of students had an interest in learning more about engineering and would participate in an engineering outreach program if their school or an afterschool program offered one. In addition, when we compared the overall interest in engineering between students who have and have not been exposed to engineering outside the classroom, we found that students who participated in an engineering outreach program had a significantly higher interest in the field. Our analysis heavily implies that if east Merton schools and afterschool programs ran engineering related activities they would not only be well received by students, but would also be successful in improving understanding and increasing interest in

engineering. We used the survey results to form an easy to read summary and breakdown of this analysis which Commonside can provide to schools, local authorities, or any other potential partner to justify the need for an engineering outreach initiative throughout east Merton. We have attached this document in Appendix H.

Alongside providing Commonside with a method to justify their proposed initiative, we also helped lay the groundwork for the future project. We designed this segment of the project to provide Commonside with the tools necessary to start a successful initiative. We determined that female students required additional focus, outlined outreach programs incorporating local history to teach participants about the history of their borough, and found how Commonside should approach private sector businesses interested in participating in the initiative.

Using our results from our student survey, we determined that compared to boys, girls seem to have a significantly lower interest in becoming engineers. From this information we determined that Commonside should not only provide generalized programs for all students but should run programs catered towards girls as they have a noticeably lower interest in engineering.

We determined the best way to incorporate local history into engineering outreach programs was to focus on the industrial history of Merton, as the borough was well known for the industry that took place there. After interviews with the Wandle Industrial Museum and research at the Morden Library, we suggest Commonside develop outreach programs incorporating the history of the River Wandle, Merton Abbey Mills, water power technology, and textile mill printing methods. As the first step in the development of these engineering outreach programs, we have provided Commonside with two draft program outlines which incorporate these history topics. We chose these topics due to the close connection with east Merton history, the ability to provide students with real life visuals of this technology, and the means to create hands-on activities to teach students how this technology works. While not specific to east Merton, we also drafted two programs based on the works of James Brunlees, a famous civil engineer who lived in Wimbledon and one program about Joseph Bazalgette, a Merton resident and chief engineer of the London Metropolitan Board of Works. Each program outline provides a description of the history, the importance of the material covered in the program, and a brief timeline of how this program would run.

Since Commonside does not have experience partnering with private sector companies, we focused on learning the characteristics of a mutually beneficial partnership and determined what different sized companies would like to give and receive through partnering in an engineering outreach initiative. From our interviews with the Merton Training and Recruitment Partnership, Root7, and Merton Community Transport, we determined that businesses seek to participate in charity to spread recognition of their business integrity through word of mouth. We also spoke with Andrew Turner from Viridor, a large waste management company with a large engineering division and discussed what companies are looking for in a nonprofit partnership. We provided Commonside with recommendations in section 5.4 *Recommendations Regarding Partnerships* on how to approach each individual company we spoke with and used the same analysis to provide more general recommendations about how to approach large and small private companies.

5.2 Recommendations Regarding Schools and Students

One of the major factors in student interest in engineering is gender. Male students were much more likely to choose engineering as an "ideal" career on the survey than female students, yet both genders were equally interested in learning more about engineering. We recommend that Commonside organize additional engineering outreach programs for female students. We recommend that Commonside advertise these programs as female-only programs and combine engineering with themes popular among local girls. Since outreach programs help increase student interest in specific subjects, the additional programs would help close the gap in interest between male and female students and ultimately increase the total number of students who choose to be engineers more than if there were no programs specifically targeting female students.

We also determined that adult influence is a major reason why some students have a low interest in engineering as a career. Students were more interested in engineering when an adult recommended them an engineering career. Most students reported that they had never been recommended an engineering career by an adult. We recommend that Commonside include parents in their outreach programs so that parents' opinions of engineering careers will be

changed at the same time as exposing students to engineering. When we created draft outlines of engineering outreach programs incorporating local history we designed one of them to include parents as well. Commonside could make a difference in how parents view engineering careers through these programs which would lead to more parents recommending engineering careers to their children. This could affect not only the students who attend these programs but also their siblings who do not attend since the parents would be more likely to recommend engineering careers to all of their children. From our results in Figures 12 and 13, from which we determined that exposure to engineering-related programs and activities increases student interest in engineering, we can extrapolate that this trend also applies to adults. We believe that parental recommendations are a strong reason why students choose their careers based on our results in section 4.1.1.5 *Adult Influence and Exposure to Programs Affect Student Interest in Engineering*.

The local St. Mark's academy teachers supported additional engineering education for students. Vice Principals Austin Sheppard and Jonathan Harris were also shared the same opinion about engineering education. We recommend that Commonside work with the St. Mark's academy to host engineering-related after-school activities in addition to those activities hosted at the New Horizon Centre. Hosting programs at multiple locations would allow Commonside to reach a larger number of students. If Commonside partnered with the Academy, they would be able to get resources from the school to contribute to the after-school programs. Additional resources will allow Commonside to run more complex programs for a larger number of students. Once these programs are established and tested, Commonside could hand over control to a school representative and offer to organize similar programs at other schools in the area.

5.3 Recommendations Regarding Outreach Programs and Local History

Through our interviews with representatives from the Wandle Industrial Museum and the Merton Heritage Society and our research at the Morden Library's local archives, we determined that the east Merton history most directly related to engineering and technology suitable to teach to 11 to 15 year old students is the industrial history along the River Wandle. Through our analysis of this information we determined several topics that would suitable as the centerpiece

of an engineering or technology oriented outreach program. To incorporate the local history of Merton into Commonside's engineering outreach initiative we recommend that Commonside further develop the outreach program drafts provided in Appendix I. We drafted engineering outreach programs that emphasize the history of the Merton Abbey Mills, a textile printing mill along River Wandle that is specific to the east Merton area. In addition, since this mill is still in operation we can also use the mill's working water wheel to teach students about water power. Alongside the programs specific to east Merton industrial history, we drafted outreach programs that teach students about influential engineers from Merton. We drafted two programs that teach students about James Brunlees, an influential engineer who lived in Merton, and railway bridges. In these programs students will design, create, and test model railway bridges providing them with useful problem solving and design skills. We also designed a program about Joseph Bazalgette, chief engineer of London's metropolitan board of works in the mid-1800s who designed the modern London sewer system, which ended the "Great Stink" caused by the River Thames and the deadly cholera outbreaks that plagued the city. In this program students will learn about the water filtration and take part in a demonstration where they will clean dirty water using filters. We designed a variety of programs; from programs involving field trips to see technology up close to a program that challenges participants with design contests. These programs will not only expose students to engineering concepts, but also give students an idea of the history of their local area and knowledge about influential engineers from the borough.

One of Commonside's major goals is to involve families in the engineering outreach initiative. In addition to meeting Commonside's goal, we discuss the additional benefits to involving parents in the initiative in section 5.2 *Recommendations Regarding Schools and Students*. As a way to involve parents in engineering outreach programs we recommend that Commonside encourage parents to join the program outlined in Section 2 Appendix I. In addition, we recommend any future outreach programs involving parents incorporate complex design challenges or construction, activities that may require additional adult supervision, or parent-student competitions. By creating outreach programs that meet these recommendations, Commonside can persuade adults to join in the activity due to the possibility that their child may not be able to participate if they do not join. Also, if the activities in the student-parent outreach programs seem too simple, parents may not feel they are needed and will most likely let their child complete the activities on their own. Even though these programs should encourage parent

participation, Commonside should ensure that in the event that a student's parent is unavailable, another adult or program assistant will be available to assist the student and allow him or her to still participate in the activity.

Since the program outlines we have provided to Commonside are only drafts and in the early development stages, we recommend that Commonside recruit additional engineers or science teachers to help finalize these engineering outreach programs. Prior to administering these programs, Commonside must test these programs to determine they will run efficiently and without any surprise issues that Commonside is not ready to address. Program developers should perform each program to determine any problems that occur during activities and if there are any parts of each activity that a younger student may have difficulty performing. While our outlines have estimated times for each program, developers should also check if the allotted time is acceptable for the activity and change time estimates accordingly. Alongside testing, Commonside or program developers must determine a budget for each program and coordinate with any recommended partners.

5.4 Recommendations Regarding Partnerships

Our interviews at Root7, Viridor, Merton Community Transport, and the Training & Recruitment Partnerships resulted in plenty of useful information regarding partnerships. When approaching a company, we believe an interview and discussion in a semi-formal environment would be the quickest and most informative way to determine if the company is a good fit for Commonside. The discussion is also an excellent time for Commonside to bring up the topic of partnerships. From our conversations, we recommend that Commonside first determine the best fit companies by ensuring their values and contributions align with Commonside's. Small to medium sized businesses are more willing to partner and have the most to gain. As defined by the Companies Act (2006), a small business has fewer than 50 employees and a medium business has fewer than 250 employees. New businesses are often seeking to prove their integrity to the community to help form profitable relationships. These businesses will be looking for low-cost outlets to promote their business, since they may not have the resources for widespread advertisement. Furthermore, small businesses in particular benefit greatly from being associated

with charities. The community sees the company name in a positive manner at a critical time in the lifetime of a business. The establishment stage is when a company is gaining a reputation and early clients. Associating with a charity is helpful for small businesses seeking local work opportunities. We recommend Commonside keep its scope to Merton and small businesses to increase local networking and gain experience with private-sector partnerships before broadening its scope.

However, large companies can also benefit from nonprofit partnerships due to the networking potentials. In Viridor's case, they would benefit greatly from a partnership if Commonside could educate the community on the technology of the incinerator. Truly, it depends on each company's unique situation. Large companies will often have a much larger budget to accommodate funding for community projects. We recommend Commonside expand their scope outside of Merton and include large companies when undertaking a new and expensive initiative. During partnership discussion, one would essentially treat a large company the same way as a small company: confirm your goals and expectations before initiating a verbal agreement. Discussing ways the company and Commonside can contribute will assist in aligning common goals. We highly recommend discussing ideas for company contributions during the partnership interview process. At this point in the interview or discussion, Commonside's representative will have enough information to determine if the company is a good fit for Commonside and willing to contribute to the community.

During our interview with Fitzroy Dawson he mentioned connecting with particularly high profile individuals. To kick-start the process and assist a neighboring charity, he provided the contact information of an individual in parliament that organizes networking "parties" in which its wealthy, innovative, and successful members post requests, along with contact information, on a note board for others to respond to. It is inappropriate to name the individual without their consent, but we believe it is worth mentioning that Commonside has their information and ultimately a way to contact the high profile people and companies we mentioned in section 4.3.1, *Insights on Private Sector - Non Profit Partnerships.*

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Appendix A

Welcome to the Commonside and WPI survey on engineering education. Thank you for taking the time to answer our questions. The survey is 13 questions long and should take less than 15 minutes. Please follow the *italicized instructions*, read everything, and answer to your best judgment.

(Q1) What is your age?

_____

(Q2) I identify my gender as...

- ❍ Male
- ❍ Female
- ❍ Prefer not to say
- ❍ Other (Please specify) _____

What is engineering?

Engineering is the use of **science** and **maths** to design or make things. Engineers learn engineering at a college or university. Engineers usually design or build things that are sold. There are different types of engineers that design everything from computers and buildings to watches and websites.

(Example jobs: Aerospace Engineer, Computer Scientist, Bio-medical Engineer...)

Please read the following questions carefully and answer them with your best judgment.

(Q3) My parent, guardian, or another adult has recommended engineering as a career for me.

- ❍ Yes
- ❍ No
- ❍ Unsure

(Q4) I have participated in an after school program that taught me about science or engineering. (For example: building a model rocket, performing science experiments, designing a robot...)

- ❍ Yes
- ❍ No
- ❍ Unsure

(Q5) I have participated in activities outside of school that have taught me about science or engineering.

- ❍ Yes
- ❍ No
- ❍ Unsure

What is engineering?

Engineering is the use of **science** and **maths** to design or make things. Engineers learn engineering at a college or university. Engineers usually design or build things that are sold. There are different types of engineers that design everything from computers and buildings to watches and websites.

(Example jobs: Aerospace Engineer, Computer Scientist, Bio-medical Engineer...)

For the following statements, please indicate your level of agreement as best you can.

(Q6)

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I understand what people do in an engineering job.	❍	❍	❍	❍	❍
From what I know, engineering is a boring career.	❍	❍	❍	❍	❍
I am interested in learning more about engineering.	❍	❍	❍	❍	❍

(Q7) I would be interested in participating in after school activities that teach me about science or engineering.

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neither agree nor disagree
- ❍ Somewhat disagree
- ❍ Strongly disagree

For the following statements, please indicate your level of agreement as best you can.

(Q8)

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I think learning maths is not important.	❍	❍	❍	❍	❍
I do worse at maths than my other subjects.	❍	❍	❍	❍	❍
I think learning about science is important.	❍	❍	❍	❍	❍
I do better in science than my other subjects.	❍	❍	❍	❍	❍

(Q9)

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I think science classes are boring.	❍	❍	❍	❍	❍
I think maths classes are boring.	❍	❍	❍	❍	❍

For the following statements, please indicate your level of agreement as best you can.

(Q10) If **science** classes had more experiments or demonstrations, I would be more likely to enjoy this subject.

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neither agree nor disagree
- ❍ Somewhat disagree
- ❍ Strongly disagree

(Q11) If **maths** classes had more projects or demonstrations, I would be more likely to enjoy this subject.

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neither agree nor disagree
- ❍ Somewhat disagree
- ❍ Strongly disagree

(Q12) I would be interested in classroom experiments or demonstrations that teach me about technology and engineering.

- ❍ Strongly agree
- ❍ Somewhat agree
- ❍ Neither agree nor disagree
- ❍ Somewhat disagree
- ❍ Strongly disagree

For the following question, please categorize each job field by writing 1, 2, 3, or 4 in each of the indicated fields. Carefully read the description of each number below and answer to the best of your abilities. You may have multiple jobs for each number.

(For example, both **Education** *and* **Science & Research** *may be marked as 2.)*

(Q13)

IDEAL (1) - The job you would most like to do.

EXPECTED (2) - The job you feel you'll most likely have after finishing your education.

TOLERABLE (3) - The job that you would be willing to take that is still acceptable.

REJECTED (4) - The job you absolutely will not do.

_____ Administration & Management

_____ Business & Finance

_____ Civil Service

_____ Computers & Technology

_____ Construction

_____ Education

_____ Engineering

_____ Farming & Fishing

_____ Health & Medical Services

_____ Hospitality & Tourism

_____ Law Enforcement

_____ Management

_____ Manufacturing

_____ Media & Communication

_____ Military

_____ Sales & Marketing

_____ Science & Research

_____ Sport

_____ Transportation

_____ Other (Please specify) _____

Appendix B

Guidelines for Interviews with St. Mark's Representatives

Hello, and thank you for meeting with us today. I am _____ these are my partners _____ and _____. We are students from the US University Worcester Polytechnic Institute, a comprehensive university with special strengths in engineering in the state of Massachusetts. As part of our degree requirement we complete a non-major specific project called the "Interactive Qualifying Project" or IQP. This is an intensive project in which we must address complex, real-world problems involving the interface between science or technology and society.

For our IQP we are working with the Commonside Community Development Trust, a local Merton charity, to assist with an initiative to promote engineering education throughout the community. The overall aim of the initiative is founded on 'local jobs for local people' and finding out what the skill gaps are for local and regional employers so that we can work with schools, colleges and other stakeholders to encourage these careers as fun and rewarding.

The goal of our project is to provide information and resources to help Commonside effectively implement this initiative. We plan on achieving this goal by evaluating the current interest in and state of engineering education in Merton, developing a strategy to incorporate local history and heritage into the proposed initiative, and creating a strategy for engaging potential supporters and partners for the proposed initiative.

Before we begin this interview, we would like to ask for your permission to record this interview so we can create a transcript for our final project report **(If yes; record the interview and have one group member take notes. If no; have two group members take paper notes of the interview)**. In addition, we would like to ask for your permission to use your name and/or position (if needed) in our final report **(If yes; use name. If no; ask if we can use their title/position. If no; do not state name and/or position in report).**

Question 1: In what ways are students exposed to engineering and technology in school?

Question 2: Do you think there is enough engineering education in school? Not enough? Too much?

Question 3: What engineering-related after-school groups or activities does your school currently have?

Question 4: What effect do you think additional engineering related after school programs would have on students?

Question 5: Would your school be able to run additional engineering related after-school activities?

- **(If no)**: For what reasons?
- **(If yes)**: What resources would you have available for these activities?

Question 6: How would your school be able to accommodate an outside organization looking to run after school programs to increase student interest in engineering?

- What issues would limit your school's ability to allow an outside organization to run after school programs? (Liability issues, transportation, etc.)

Transcript of Interview with Vice Principal Austin Sheppard

Matthew: Hello, and thank you for meeting with us today. I am Matthew Haley this is my partner Andrew Rathbun. We are students from the US University Worcester Polytechnic Institute, a comprehensive university with special strengths in engineering in the state of Massachusetts. As part of our degree requirement we complete a non-major specific project called the "Interactive Qualifying Project" or IQP. This is an intensive project in which we must address complex, real-world problems involving the interface between science or technology and society. For our IQP we are working with the Commonside Community Development Trust, a local Merton charity, to assist with an initiative to promote engineering education throughout the community. The overall aim of the initiative is founded on 'local jobs for local people' and finding out what are the skill gaps and,- for local and regional employers so that we can work with schools, colleges and other stakeholders to encourage these careers as fun and rewarding. The goal of our project is to provide information and resources to help Commonside effectively implement this initiative. We plan on achieving this goal by evaluating the current interest in and state of engineering education in Merton, developing a strategy to incorporate local history and heritage into the proposed initiative, and creating a strategy for engaging potential supporters and partners for the proposed initiative. Before we begin this interview, we would like to ask you for permission to record this interview so we can create a transcript for our final report.

Mr. Sheppard: Absolutely, no problem.

Matthew: So, the first question we'd like to ask you is "in what ways are students exposed to engineering and technology in school?"

Mr. Sheppard: Well, in, in the school at the moment we have a strong priority around the core, what we would call the core subjects of maths, English, and science, so, obviously two of the major elements that feed into technology careers being science and maths. So students get six lessons a week so that's at least one lesson in maths and one lesson in science every day throughout their whole, their whole time that is up until the end of year eleven, the age of sixteen. And then we have significant pathways into our sixth form so B-Tech pathways and A-Level pathways for those students so we have a strong A-Level maths program, a strong A-Level physics program, and chemistry within sciences. And they're able to do that. One of the things which is a massive opportunity and gap in what we do is, is technology itself. It was taken,- prior to me working at the academy three years ago, technology itself was take off of the curriculum. What we've worked hard on this year is to have a,- to re-establish that. So September 2016 technology is coming back onto our curriculum as a, an option in our examined subjects. So we'll find,- we'll have resistant materials, design technology back on, back on the curriculum, to open up again a clearer pathway into those. On top of that we do have technology used across the curriculum, so there are,- students do get exposure to ICT resources and interactive whiteboards and some of those technologies. And we use some web based technologies for things like homework. Again that is a massive area of opportunity for us to develop and we've got a new ITT contract in place, again from September 2016, where we hope to secure what the facilities we've got and the resources we've got and then develop them further. So starting to look into things like bring your own device to school, students, having the students make greater use of things like iPads and laptops in lessons as part of the curriculum. So as we look towards the future, and develop that further.

Matthew: So, I might already know the answer to this question based on what you just said but, a little more in detail, "do you think that there is enough engineering education in school right now? Or not enough?"

Mr. Sheppard: I think on a personal level I'd certainly like to see more. And on a strategic level, the school, you know we've made a real commitment to ensuring that technology is back on the curriculum. Our students are keen and eager for it, there'll be strong uptake. We see it as sort of a staged process whereby we want to make sure that the curriculum we offer is the best it possibly can be for our students and we believe technology is a key part of that. So, I'd anticipate over the next five years seeing an increase in our provision with that. And we would,- I wouldn't anticipate any kind of taking away from any of the resources that we're currently putting into maths and science, because we know they're the fundamentals to help students make those choices if they're getting high quality provision in science and maths. Particularly with science we've put extra money into our recruitment of teachers. And, so again from September 2016 we're looking to looking to make sure that science is resourced with high quality staff with experience. So yeah, top priority really.

Matthew: Okay. And, what engineering-related after-school groups or activities does your school currently have, if any?

Mr. Sheppard: Well, the engineering enrichment as a club-style element is not as strong as it could be given that we don't have a technology teacher on,- running lessons on the curriculum currently. So that would be again linked to the rebirth of that,- of those subject areas, with having some expertise in to rejuvenate that. Given the life cycle of the school where we're at where we know that the outcomes of exams are vital for our students and their success in the next stage of their careers what we actually focus on a lot of our after-school clubs is actually curriculum intervention. So extra support for those students who need it to succeed in their school, in their school studies at maths and science, so that we have a strong enrichment program for maths and science where on allocated days during the week different year groups come for extra support based on how they're doing. We've also looked into,- with some of our most gifted learners, particularly maths and science learners, we look to try and get them out on enriching trips so they can go to visit universities, where they have the opportunity to visit universities and encourage them to think of that as a future pathway for them, but specifically to look at engineering departments and science departments and maths departments and, to figure out those next steps. And we do a lot of,- in fact tomorrow we've got the junior maths challenge which is a national challenge, like an examination but of problem-solving questions that we aim our gifted and talented students to give them those extra opportunities in there. So clubs is an area we want to push further but we do a lot during the curriculum time and within trips in our other provisions for G and T, to do as much as we can to push those areas forward because they know the STEMs subjects are really vital.

Matthew: Okay. So, with that in mind, you mentioned that you think that's an area that could be added onto and improved on, would you be able to accommodate like an outside organization such as Commonside looking to help run these after-school programs?

Mr. Sheppard: Absolutely. We'd,- in fact not only would we be able to accommodate them we'd be really welcoming of any support that we can get. You know, as a school we've done that with other things so, I'll give you an example we've got the RFU the Rugby Football Union now come in one day a week to help us establish rugby as a new sport with our students. You know, an area where we felt the students could develop further in their sports, so working with outside agencies is actually something that we are really on board with and that we value.

Matthew: Okay. Are there any issues that could potentially come up in the, kind of running these programs with an outside organization like liability issues or transportation after the program or anything like that?

Mr. Sheppard: Sure some of those issues do arise; I think hosting on-site is logistically a good option for us. Because sometimes when we have to transport students elsewhere that does bring huge logistically errors and encumbering other issues so I think my preference would be for outside support to come on-site. There would be the usual child protection issues and sort of support barriers, but nothing that we've, we haven't done before and nothing that's unsurmountable in that direction. And as I've said there's key areas of improvement I'd have some really key players that would be on board for doing that, so our new technology member of staff is actually going to come in as a head of department so we'd have the authority and the capacity to really drive that forward so I would actually say nothing that's unsurmountable.

Matthew: Okay, well that's great to hear for us! And I think that's what we needed to hear from you.

Mr. Sheppard: Right, perfect.

Matthew: Thank you, we appreciate it.

Transcript of Interview with Vice Principal Jonathan Harris

Matthew: Hello, and thank you for meeting with us today. I am Matthew Haley and this is my partner Andrew Rathbun. We are students from the US University Worcester Polytechnic Institute, a comprehensive university with special strengths in engineering in the state of Massachusetts. As part of our degree requirement we complete a non-major specific project called the "Interactive Qualifying Project" or IQP. This is an intensive project in which we must address complex, real-world problems involving the interface between science or technology and society. For our IQP we are working with the Commonside Community Development Trust, a local Merton charity, to assist with an initiative to promote engineering education throughout the community. The overall aim of the initiative is founded on 'local jobs for local people' and finding out what the skill gaps are for local and regional employers so that we can work with schools, colleges and other stakeholders to encourage these careers as fun and rewarding. The goal of our project is to provide information and resources to help Commonside effectively implement this initiative. We plan on achieving this goal by evaluating the current interest in and state of engineering education in Merton, developing a strategy to incorporate local history and heritage into the proposed initiative, and creating a strategy for engaging potential supporters and partners for the proposed initiative. Before we begin this interview, we would like to ask for your permission to record this interview so we can create a transcript for our final project report.

Mr. Harris: Yes, you have it.

Matthew: Okay. So, the first thing we'd like to ask you is "in what ways are students exposed to engineering and technology in school?"

Mr. Harris: No,- we have the science department who of course would, I suppose in their own way, provide some sort of experience of engineering. However I can't tell you exactly what that is because I'm not a member of the science department. What we have recognized, is we've recognized the gap in our curriculum for technology. And so we're re-introducing our product design to the curriculum this year. So that's going to come in to year seven and eight and will be a GCSE option for us in year nine. So we're going to try, if we can, to sort of rebuild that area of our curriculum. What we have noticed is that there are a large number of students who, when they leave us at the end of year eleven are applying to colleges such as Kingston College for aircraft engineering or things like that. Now, for us, I don't think we prepare students well enough here to move on to destinations like that. Now what we do for certain students is we have a relationship with South Thames College and for certain students in year ten or year eleven we have car mechanics and motorcycle mechanics that we offer to those students. However that's completely different from engineering, and again is not going to support students well enough to give them the skills necessary to go on for engineering courses or even degrees.

Matthew: Okay. You mentioned that you are starting to address that gap this year. Do you think that once all of these changes are in place you'll be preparing students well enough for these,- to pursue these degrees further?

Mr. Harris: No, I don't. Because when we reintroduce technology to the school we're looking at product design. Now product design in its very nature is the design and creation of sort of objects or,- very very few students would go ahead and look at electronics or machines or anything like that. So, so no, I don't think it does prepare students well enough.

Matthew: Okay. Do you think that potentially this gap could be closed by additional engineering-related after-school programs? That are targeted toward engineering education or do you think it still,- there's just too much of a gap?

Mr. Harris: Well you see what we haven't done is we haven't done a skills audit of our staff. In a sense, we know what our staff can teach and what qualification they've got but any particular interests that they have perhaps outside of the workplace they could offer as enrichments. We haven't done that sort of skills audit. And perhaps that's one thing that we could do, but again we would need to look at resourcing any sort of enrichment and there would be a cost implication for that. And we're looking at a ten to fifteen percent reduction in budgets over the coming years so how on earth are we going to support our own curriculum let alone move forward then for enrichment offers?

Matthew: Okay, so, just, part of that would be,- these after-school activities, if outside organizations were looking to come in and assist or just entirely run these activities that could help with-

Mr. Harris: Well what we do is we see an advantage in the white paper that the government released in March, and what we can recognize there is that there'll then be twenty five percent of schools that've then got to extend their school day in order to provide enrichments. And the government has set up a fund that we can apply to for money for these sort of enrichments. However the disadvantage that we've got, although we're in sort of an area of deprivation, we are within the (inaudible) twenty five and we are within London. And so when they're looking at these sort of achieving excellence areas I can't see that we will fit into those areas, because they're mainly looking of course to costal schools which has massive underachievement or perhaps the northwest of England.

Matthew: Okay, so in terms of these just outside organizations, even such as Commonside or any of the partners for their initiative coming in to run these programs, do you think that would be a suitable way to address a lot of this skill gap?

Mr. Harris: I don't know anything about Commonside. Who are Commonside?

Matthew: So, we said that we're working with them, they're just a local charity, they run a lot of programs in the community. They run a community center five or ten minutes from here and are looking to kind of help increase engineering knowledge in the borough.

Mr. Harris: Certainly, we would welcome it, massively. Because it's a gap isn't it? And we're meant to be preparing students for destinations and tracking students more carefully. Well we're not doing that at the moment if they're,- if they have a particular interest in engineering.

Matthew: Okay. So, Andrew do you have anything to add, extra questions based on what he said or?

Andrew: So, bringing sort of like outside people to help run the outreach program, like Commonside, that would help a lot of the budgetary issues you were discussing, correct?

Mr. Harris: Yes.

Andrew: So you'd welcome that just for that aspect.

Mr. Harris: Completely.

Matthew: I guess my last question based on everything is you,- since you say you're not being able to provide enough for these students that want to go down this path, how much,- to what extent would the information in these programs need to be, how much would need to be covered? You don't have to say exactly but do you think it would be,- there would need to be a lot of programs with a lot of in-depth education in them or would it just be a little bit of additional information and useful programs to help these students get to the point where they need to be?

Mr. Harris: We've got a very good relationship here with Kingston College, and what I think would be sensible is, that if they looking at supporting us with something like this, is perhaps what we do is we contact the college and meet with them and find out what they would see as a good basis,- they,- or rather a good basis for enrichment that would not only spark young people's interests but sort of give them just a little bit of a foundation, and so perhaps it would be good if we spoke with them and then they could backward map for us.

Matthew: Okay.

Andrew: Good idea.

Matthew: Yep. That's all we have to ask you, that was very useful, thank you very much for your time.

Mr. Harris: Fantastic! And you're ten seconds under ten minutes, that's brilliant.

Interview with St. Mark's IT Coordinator Max

Matthew: Hello, and thank you for meeting with us today. I am Matthew Haley and this is my partner Andrew Rathbun.

Max: Hello

Matthew: We are students from the US University Worcester Polytechnic Institute, a comprehensive university with special strengths in engineering and,- in the state of Massachusetts. As part of our degree requirement we complete a non-major specific project called the "Interactive Qualifying Project" or IQP. This is an intensive project in which we must address complex, real-world problems involving the interface between science or technology and society.

Max: Yes.

Matthew: For our IQP we are working with the Commonside Community Development Trust, a local Merton charity, to assist with an initiative to promote engineering education throughout the community. The overall aim of the initiative is founded on 'local jobs for local people' and finding out what are the skill gaps for local and regional employers so that we can work with schools, colleges and other stakeholders to encourage these careers as fun and rewarding. The goal of our project is to provide information and resources to help Commonside effectively implement this initiative. We plan on achieving this goal by evaluating the current interest in and state of engineering education in Merton, developing a strategy to incorporate local history and heritage into the proposed initiative, and creating a strategy for engaging potential supporters and partners for the proposed initiative. Before we begin this interview, we would like to ask for your permission to record this interview so we can create a transcript for our final project report.

Max: Yeah, we can proceed with that.

Matthew: Okay. So, given your position here, what kind of technical barriers would there be to any like, programs run with outside organizations, like after-school programs?

Max: The barriers would be obviously the security issues is the first issue. Security issues regarding data, and protection, protecting the students from outside sources and the school's network also. So other barriers could be the type of system and devices that we have available that should be upgraded or even improved. Yeah, I mean at the moment we have a system which is eight, nine years old. So that could be a, be a barrier for getting involved the,- more people or students in some kind of project or any other,- yeah plan regarding their involvement in any educational project. So other barriers could be the level of knowledge of the students, regarding IT science. Which is quite low, I reckon. You would expect more from the students especially when you see them using their smart phones and you think they might be more capable but actually they are not. Knowing to use,- knowing how to use or manage an iPhone doesn't necessarily mean they have enough knowledge to get involved with any IT project or any other project that has to do with IT devices. So these are the main issues, security, the level of knowledge, and the system or the hardware itself. So it could be improved or upgraded, and giving more chance to the students with staff to have more,- to explore the resources. That's I think the main issues, the main barriers.

Matthew: Okay, so do you think that,- well what ways do you think those kind of issues could be worked around?

Max: Investing in terms of infrastructure, investing in a new sort of educational system regarding this specific issue. Perhaps investing in more, in how you say, in people who can lead,- who can guide these people and the staff towards a certain project. These are a matter of how much effort and money, financial, how much (inaudible) you put in this kind of project.

Matthew: Mr. Sheppard had mentioned that the whole IT system here,- the plan is kind of to get it more up to date and kind of boost that section of the school.

Max: Yes.

Matthew: So moving forward with these changes being in place, or as they become implemented, what kind of affect do you think that would have on being able to get past these issues. Like it would hopefully eliminate some of them entirely, but what changes do you see that moving forward we would be able to expect?

Max: As I say the changes,- the first issue is how,- in what way the school or even the academy which is a part of a trustee (inaudible) they have more than twenty schools, so the first things we have to see what is the potential, what is the,- what they have available as resources to invest in this section. I'm not sure to be honest with you in terms of their availability. Because they could tell you, okay let's do this kind of project or plans but if you don't have means to, to implement that idea so there would be promises and things like,- so it's depend on the practical things that you come across. For example: a new company is supposed to take over and do the, upgrade the system, but if I told something but I didn't have the means to implement it, so, it doesn't really work, it wouldn't work. But as I know because in general in UK they are tightening the budgets for educations and they are trying to reduce it, rather than,- so that would cause some disruption or even.- I'm not sure about the,- because you know it's all matter of what you have available because you have ideas but potentially if you don't have the means you can't do much really. I mean I could tell a student we will do this we will do that, but in a practical term at the moment I can't see any further than what we have now.

Matthew: Okay, so would you recommend that any outside organization looking to come here to run programs try to keep the technology they need available here to a minimum or would you say they can try to work in the technology and see where that leads?

Max: Any company, anybody from outside obviously is,- would have a general view of the issues. What you should work within this environment, with the students, with their specific needs and say then okay we need this, we need that, we have to upgrade this, we have to improve. Having a general issue, having a general view, won't solve the issues, because not every one are the same, not all the schools are the same. I think that companies should stay in,- work within this environment with the people and understand their needs and then move forward. Isn't something a standard, I know, because the IT issues for example each school, each environment has their own needs and, yeah, is not something you can apply to all,- any environment with a kind of scheme or cliché, it doesn't work like that. For example: if you say we might have a project for students to introduce them 3-D printing, making objects. Obviously it's not only the IT equipment that you need, you need people that are instructed to do so, and to teach and to do,- and then you need equipment and you need people who look after this equipment. Just an example. Or for example: bringing your own device and trying to interact with the network and IT, your own device rather than relying on a,- all these things you have to stay in the school you have to work with the students and the staff and then come with ideas, you know, interacting with the students and come with the concrete ideas rather than general views. "If these things work here, certainly it's gunna work somewhere else." I think that's not the way to do so. Personally I think that,- now is the trend is you get a frame and you apply it to everybody and say okay, because this works somewhere so it should work everywhere. Yes, because this school for example is a big school, and the students have different backgrounds, majority of them are not born or (inaudible) in this country. So you have to consider all this specs and then go through the project. It might be language barrier, it might be, I don't know, anything related to the backgrounds, people's backgrounds, students' backgrounds. Well you might say what has to do with IT or what has to do with technology, I think it's important to know first the individuals and then relate with them in terms of, you know, understanding them, and then make a plan that is suitable to the environment and the individuals that work and study in this environment. If I say for example, the 97%, more than, almost 100% of the students sixth formers, when I ask them what is your aspiration, what are you looking for your future, they all talking about business, I'm really surprised. How could the people,- everybody do business? So who's going to buy from you, is somebody,-

because this everythings now focused on business and marketing and that's not really good news. Not everybody should do marketing and business, because then you might think marketing and business has to do with maths or calculation or none of this. I realize it's most these students are not good in maths or science and they want do business. It doesn't sound right really. So the first thing if you want to move forward for any project you have to work on the basement, the foundation. If I encourage all the students go for business and marketing, I don't think that the future would be really promising. So we can't rely on everybody's own,- so if you go doing a survey, interviewing students, sixth formers, for example, year 13, you will always hear the same answer: business marketing. Because for example there was a, apprenticeship program (inaudible) for IT, before that I thought I'm gunna have a good few students that they were really interested in IT because all these devices and technology so it comes natural that you wanna know what is behind this devices. But I had a really bad surprise, only three people were interest. So this is quite worrying, like you want to have devices and use devices but you don't want to learn, and make any effort to get it to the, you know the system, that's a problem. Yeah.

Matthew: That's all the questions we had for you.

Max: Yeah, good.

Andrew: Thank you.

Max: If you need me give me a shout.

Appendix C

Guidelines for Interview with Wandle Industrial Museum Representatives

Hello, and thank you for meeting with us today. I am _____ these are my partners _____ and _____. We are students from the US University Worcester Polytechnic Institute, a comprehensive university with special strengths in engineering in the state of Massachusetts. As part of our degree requirement we complete a non-major specific project called the "Interactive Qualifying Project" or IQP. This is an intensive project in which we must address complex, real-world problems involving the interface between science or technology and society.

For our IQP we are working with the Commonside Community Development Trust, a local Merton charity, to assist with an initiative to promote engineering education throughout the community. The overall aim of the initiative is founded on 'local jobs for local people' and finding out what the skill gaps are for local and regional employers so that we can work with schools, colleges and other stakeholders to encourage these careers as fun and rewarding.

The goal of our project is to provide information and resources to help Commonside effectively implement this initiative. We plan on achieving this goal by evaluating the current interest in and state of engineering education in Merton, developing a strategy to incorporate local history and heritage into the proposed initiative, and creating a strategy for engaging potential supporters and partners for the proposed initiative.

Before we begin this interview, we would like to ask for your permission to record this interview so we can create a transcript for our final project report **(If yes; record the interview and have one group member take notes. If no; have two group members take paper notes of the interview)**. In addition, we would like to ask for your permission to use your name and/or position (if needed) in our final report **(If yes; use name. If no; ask if we can use their title/position. If no; do not state name and/or position in report).**

Pre-discussion Questions

- Do you mind describing the Wandle Industrial Museum?
- ...your role at the organization?

Discussion Questions

- Could you explain any historical sites or locations that are of local importance?
    - Ask specifically about the topics listed **below**
    - Ask if they can describe any additional sites or locations
- Has the industrial history of Merton had an effect on the local culture?
    - If yes; ask if they can elaborate
- Are there any other local resources you recommend to further our research about the history of Merton/Mitcham?
    - Mention we used the Morden Library as a resource

- How can we utilize your organization's resources to develop in-school or after-school programs designed to teach students about engineering?
- Does your organization already run outreach or information programs for students?
    - Would your organization be willing to modify these programs to incorporate aspects of engineering education?

    - Would your organization be able to run these (existing or modified) programs in conjunction with Commonside?

- How do you think we could utilize the industrial history of Merton/Mitcham to promote engineering education to the local youth?

Additional Topics to Discuss (Determined from Prior Research)

- Holbourn Industrial School
- Importance of Grove Mill
- Types of industry seen in the Industrial Parks around the River Wandle

Transcript of Interview with Volunteers at the Wandle Industrial Museum

Andrew: Okay so, we are, us three, we're students from Worcester Polytechnic Institute which is a engineering school in Massachusetts. And as part of our degree requirement we complete a non-major specific project which is called the Interactive Qualifying Project or IQP as its known. This is an intensive project in which we address complex real-world problems (fill in) between science and technology in society. So it's more, it's not, major-specific, and it's not, it's less technical and more social sciences and more humanities focused.

Dasan: So, we're all engineers here.

Andrew: All three of us are engineers.

(Brief inaudible discussion – 4 voices at once)

Andrew: So for our project we're working with Commonside, which, I already mentioned earlier. And they're, what they want to do is they want to create and initiative to promote engineering education throughout East Merton, because I'm not sure if either of you know there's been a shortage of engineers recently. And Naomi who's the director wants to help fill that, that gap, that shortage in labor, so she's using us to kinda set the ground work, for her, for like outreach programs. And one of the things she wants to do is she wants to kinda give the project a local identity and to involve the local history of the area 'cuz we've learned, you both know very well there's a lot of industrial history in the area and that relates to engineering and she wants us to figure out how we can incorporate it in programs.

(Brief inaudible discussion – multiple voices)

Andrew: And it's like, technology, stuff like that.

Allison: You're not expecting too much, engineering from us?

Andrew: No, no, that's perfectly fine, that's, that's our job.

(Inaudible – multiple voices)

Andrew: To see how it relates to engineering.

Mick: (Inaudible for a few words), you need to talk to Eric before you go.

Andrew: Of course

Mick: Because he used to work for (fill in) local firms.

Andrew: Okay

Dasan: Perfect.

Andrew: Alright.

Mick: Based in, on, making alloys.

Dasan: Wow.

Mick: Yeah, so he might be interested to talk to you.

Andrew: Okay

Dasan: Of course.

Andrew: Alright, so before we, before we begin the discussion I just gotta get on record that both of you are okay with us recording the interview.

Mick and Allison: Yeah.

Andrew: Okay. Alright. Let's begin. So do both of you mind saying, or, briefly describing the museum and saying like your role in the organization?

Mick: You go. (to Allison)

Allison: Okay. Well, I'm Allison Cousins, I'm the honorary archivist, I don't know why its honorary, but (fill in), just, I think they can get out of, you know, keeping me on if anything happens. So I am supposed to, well I emphasize a lot supposed, supposed to catalog, receive donations, catalog them, make sure they are secure, make sure, they're not, they haven't got any problems, and, they're not contaminated or anything. We haven't yet got a database to do that. But we will keep working on that. And, we don't get many donations. Because as you can imagine the industries are so old. Nothing recent is coming along, what we do tend to get is maybe sorta scarves and fabrics and things like that related to William Morris. Or photographs, or, information, printed information. So not, you know, major articles that, used to be in the factories or things like that. We already do have quite a bit of that from the essential oils, so that would be lavender, water, cress(?), and that sorta thing. We've got a little bit of technology from a company that used to do rubber chest expanders.

Andrew: (inaudible interjection)

Allison: So, little bits of everything. We're also currently digitizing our photographs, black and white photographs, we're simply doing the digitization at the moment we haven't done the cataloging for it. But because we haven't got a curator, we haven't got an administrator, basically there's a team of us of four people doing an operations team work, we're all doing everything. So whereas I should be sitting down cataloging, I'm not, I'm panicking or thinking "who'll cover the opening next Sunday?" So at the moment this last year has been a bit difficult.

Andrew: Okay

Allison: So our roles are not terribly specific.

Andrew: Okay

Allison: We're all mucking it together, and last year we did an exhibition as a group, and you say you should never do anything by committee, but it worked, which was maybe just luck first time but, I don't know. So that is my official role as archivist, to record what we've got, to run the little library thing, and possibly doing sort of outreach, so I join with Mick to do talks and printing workshops.

Andrew: Okay

Allison: So, Mick, Mick does everything else.

Mick: Sort of, my official role is to sit out at the front there, and look after the visitors coming in. I can't remember the last time I actually sat out at the front there, but yeah I, do you want the museum bit as well though don't you?

Andrew: Yeah, sure!

Mick: Yeah, let's tell you a bit about the museum. The museum was set up by two people in 1983, those people were concerned that one of the industrial sites that we've got in Merton, which we now know is at Merton Abbey Mills, was going to be demolished. As a result they thought the heritage along the river Wandle was gunna get lost. So hence, they set up the museum. Until 1996 we were based, we were nomads, we were based in a couple places in Wimbledon for a short period but unfortunately one of those properties had a fire so it destroyed some of the material we had. We then moved into this as a temporary building in 1996 and we've been here ever since.

All: (laugh)

Mick: And we're still temporary. As a temporary orginazi- as a temporary building, and in a building where we don't have a lease…

(knock on the door, David enters)

Mick: Hello David, this is David.

All: Hello

Mick: We are unable to get lottery funding because we haven't got a lease for the building, and one of the requirements for getting funding from the lottery, national lottery, is by having a lease for the building, and we haven't got that, which is unfortunate. But anyway, we do have… we do try to keep the heritage alive. Heritage at all to do with the river Wandle, the river Wandle stretches from Croyden and (fill in) in the south, and goes up through Croyden, Sutton, through Merton, into Wandsworth, and comes out in the river Thames.

Andrew: Okay

Mick: At Wandsworth, in its heyday it was probably the most industrial river in the country. It had a large number of mills along the river, and we concentrate here mainly on the industries that actually used the river itself, so it would have been those associated with having water wheels.

Dasan and Andrew: Okay

Mick: And use them to power. In saying that, the kind of products you had along there was gunpowder, was produced, iron was produced, copper was produced, paper, and the largest industry you had was being produced by the Argonauts(?) in the late 17th century was Calico, printing.

Andrew: Okay

Mick: Over twenty of the industrial buildings along the river were Calico works. The best example of that is what we now have- is what we now know as Merton Abbey Mills, which was formerly used by Liberty, Liberty of London, that's where they had their printing done. Queen of England and her sister Princess Margaret certainly had a lot of dresses printed there, even dresses they're wearing now they had printed there. And that's probably the largest example; it's got the last working water wheel on the river as well. In saying that, we've got a model out there that's got 49, shows 49 locations of mills, it's told that at one point there might have even been 200 mills on the river. That would have meant having a mill every 110 yards. Sounds impossible but it comes down to how they count 'em, whether they count the water wheels, whether they count the number of stones they have, 'cuz you know, coal milling was doing brilliant, you ever heard of (fill in – whatney's?) you ever heard of Young's? Those breweries way over there, look up the pubs while you're here, alright, you'll see Young's pubs all over the place. They used the water out of the river Wandle to make the beer.

Dasan: Ah

Mick: At one time. They had that as well. There was gunpowder, snuff, the tobacco product you probably are familiar with. That was made down at Calico printing took place. There was a lot going on along the river for- and it's really only within, it probably only stopped about 50 years ago.

Dasan: Alright, that's, quite recent actually.

Mick: It is quite recent, it's really only 19, sort of early 1980s it really started to disappear, and you saw the paper mills start to go. They went, Liberty's went, they moved out of they area. (inaudible) and so when they went, Young's has now gone as well, Young's was probably the last to move out. They were taken up by a company called Wells up in Bedford. They probably went about 4 or 5 years ago. By that time they had stopped using the water in the river by the way 'cuz it had been over polluted. The river itself in the 1960's was actually described as an open sewer. (Inaudible) there's a film out there that was made in late, probably around 1959, 1960 you can see what the state of the river was. It was also an interesting video because it actually shows you some of the waterwheels working as well. Okay, so that's really sort of brief history like of the, of the museum. Yeah we try to keep it going. In terms of my role I look after,- well I don't actually,- I give the information for someone to put on the website, as Allison said we do lots of stuff on the displays, we do the outreach program that we have, we go out and give talks to groups, work mostly with schools. So we try to keep heritage going (inaudible).

Dasan: Could you tell me a little bit more about the outreach program?

Mick: Well the outreach program, as far as that goes, is very simple. If it's a school, we do also do adult groups as well they're very similar, in terms of that we focus,- really because its mainly the Merton schools, we would focus on Liberty's and William Morris, who were the two main printing companies in this, in this area, at the time, so we would go out and talk about them. 'Cuz they're normally young children, it's normally what we call Key Stage 2, like 8, 9 year olds, that really get involved in it. They have a requirement for local history, so it's not normally the teenagers that we get involved in with that. And we go out and we give them a short talk, we show 'em some of the fabrics that were actually produced, and then what we do is we show 'em a film how the printing used to be done using wooden blocks. Wooden blocks that they actually used to do the printing, we can talk about that a bit more. We show 'em the film and then we get 'em to print something, see those three patterns up there, they use some small little blocks they will then use to print one of those for themselves which they then get to keep.

Andrew: Okay.

Mick: Which is quite cool, and that takes about an hour and a half overall, with, with all the printing etc. So that's normally enough for it, but even adult groups love printing those, they think it's quite actually quite unique to actually take something home. Don't tell Naomi this because she probably didn't do this with her daughter, because we don't do this when somebody comes in from outside, we only do it with groups. In terms of the talks we give a number of talks, we go in,- we, talk about the river in general. We go out and talk about the mills, along the river (inaudible) with those. (Inaudible) we'll go and talk about brewing, 'cuz her husband's a, member of the (inaubible – Mick and Allison talking over each other). We also,- we talk about lavender, and what's the other one you do? You do another talk as well, you do lavender and brewing.

Allison: That's enough.

Mick: That's enough, all right. So we, we do those, and Eric out there when we get asked, he will go and talk about the first public railway in the UK which was the Surrey Iron Railway, which was set up by the, the mill owners. So they set that up, lasted for about 30, 40 years. Or it was set up, and then the (inaudible) but it never actually, because the wars stopped, 'cuz we beat Napoleon, we were quite happy. Don't go to Waterloo though, because you would not believe that we won at Waterloo, we beat Napoleon (Inaudible – Mick, Allison, Andrew, and Dasan).

Allison: Mick's being very modest, he is a fantastic photographer, and he has recorded what, is in these situations now, and we've got the old black and white photographs that show what used to be there. And Mick's very good at doing sort of, comparative presentations, he's done presentations for so many groups and it all in context for people 'cuz you can't see a thing now.

Mick: No, a lot of it doesn't exist. Lot of it's hidden away. Yeah, we're going, supposed to be going to, Ravensbury Mill, which is quite local and that's got two waterwheels in it, but you wouldn't,- you ask anybody they can't see the wheels, they don't know they're in there, they're not working its gunna cost about £200,000 to get each wheel working, so it's gunna be a lot of money for it but,- yeah, and a lot of it's gone, some of it (inaudible). The Wandsworth end of the river, there's really none of the industrial buildings left, even with Young's they kept (inaudible) one other building, redeveloping the site at the moment, but the Wandsworth end of it there's really nothing left, only when you get down to the Merton bit you start to see some of it, there are some of the houses left (inaudible) the mill worker's colleges, there's three or four sites of those still along the river that still exist, and you get a little bit toward the south you start seeing a little bit of,- some of it is left. But certainly Merton's probably got the highest bit, 'specially with Merton Abbey Mills,- that's really, if you like, history and what the museum tries to cover.

Andrew: Okay, so speaking,- talking more about your outreach program, if Commonside goes through with this project and is interested in kinda incorporating your outreach program into a more like engineering education based thing, would you be willing to help out with that.

Dasan: It would be directed at younger kids too.

Allison: It depends on the definition of engineering.

Mick: Yeah that's what it, that's what it would be.

Andrew: To teach them more about the historical technology.

Mick: In terms of talking about what the industries were, and explaining, in terms of technically talking about how the industries worked, we probably haven't got the expertise to do that, certainly the nearest we could get to that is giving some fill about how, within the mills, where you got a coal mill you had two stones and the stones work like that, okay, whereas in the snuff mill they were like that, they were on their edge, okay, and talking about fulling mill, or a copper or an iron mill, they were hammers. So we can talk a little bit,- degree, but that's very very-

Andrew: Yeah, it wouldn't be talking about the more technical stuff, but what we're trying to do is kind of, more introduce students to this, like,- about like the industry and kind of how it works, just to kinda spark an interest.

Mick: (inaudible) talk about the different industries that were along there and what the products were that they produced, without too much, too much of an issue-

Allison: I think a good place to start-

Mick: And how, technically, how, especially the printing, how that would be, what the processes were within the printing, you know, take you through a process with that. You design,- you want this pattern, so what we're gunna do we're gunna take that patter, now I need someone, we gotta print this out, so what we're gunna do, first stage is we gotta build a block, and if we got something that's multi-colored, and how many colors are in that?

Andrew: A lot

Mick: Take a guess, a lot.

Dasan: Plenty

Mick: Well each color, with block printing, needed its own separate block. So, William Morris had one that had thirty four colors in it, so he had thirty four separate blocks, but each block, the pattern had to be drawn up. So you got someone who sets that up. Then you got the person who makes the individual blocks, and this is the process they had. To learn to be a block maker took seven years in an apprenticeship. So, if you're in engineering you're obviously, probably going to go into an apprenticeship so you can (inaudible) for that. You then got the per,- that's (inaudible), you got that person, but now you gotta make the colors. So you got someone who was a dyer who would've mixed to make the colors, now up until about 1859, all the colored dyes that were used were natural dyes, they were all made out of plants. In 1859 synthetic dyes all of the sudden arrived, totally different process, and that was when we had the downfall of the river.

Andrew: Yeah, because of all of the chemicals, correct?

Mick: The chemicals.

Andrew: I've read about that.

Mick: So you've got the dyer. Then you've got the person who's got to do the printing. So you got the printer and the tearer, and they're all seven year apprenticeships, and each of those stages that you actually go. So we can talk along, saying that these are the stages that are taken into account. That's, to a little degree, what we do. In a way, on that side, that's what we can talk about. You get into things like gun powder we haven't got a clue.

Allison: But, we, we would start from, we have a relief map out there which you can see shortly, and it shows the Wandle valley. What we would do is tell the kids, you know, water pow,- how water power drove all of these mills.

Andrew: That would definitely, that would be very good

Allison: Because they don't understand, you know, how things worked, before they just clicked switches. So that's the basic concept, and then we would go on to describe the different types of mill, or as Mick just said the different types of craft. 'Cuz, I mean this was a craft, printing was a craft, the mills produced other things. So,-

Mick: Yeah, and that was one way to printing, the other way was copper plating, copper plating was only one color, copper plate a lot of times had to be supplemented, you had the copper plate, so you printed the base color, then they used to print on top of it with blocks.

Allison: Shall I go get Eric? I'll swap over.

Mick: Yeah, alright.

Allison: Yeah, I think you need to speak to Eric.

Mick: Yeah, chat with Eric.

Andrew: Alright.

Mick: What's interesting,- what we cover, what we talked about there, is the ones on the actual river themselves, the ones that use the power of the river. They also had other industries here, particularly in this area, that didn't use the water power. So up here, (inaudible) well know, is varnish works. (Inaudible) makers. The paint people. Had a lot of those in this area, you see as well.

Andrew: Yeah, we actually did read about that, because-

Dasan: Paint and varnish producers-

Andrew: Yeah because of,- it was known as an industrial area so even when they didn't need the mills they said okay this is where all the industry is we're gunna move in here anyway.

Mick: Yeah, but they worked in (inaudible), they still had it, they still had the mills there. But you also had other industries along, see Eric worked for what we call Fry's Metals, an alloy company, so you had that which was near at Tandem Works. You had other,- you know, talked about paper making in somer town, and I forget the name of the company now, but in somer town there was a large paper producer, but it didn't use water power, even though it sat right on top of the river. So you had people like that. Tri-Ang, Tri-Ang toys, (inaudible – multiple voices), they were local. Over here, they were in Morden, on the Lombard estate. So again there were local industry with what they were producing. So there are other industries that were, were along the river, and what was (inaudible), Caulfields we just done, Caulfields is,- they produced kitchen ware, utilities, you know, utensils. Colanders and all that sort of thing. Sauce bins and that kind of thing.

Eric: In fact, (inaudible – Eric and Mick).

Mick: So you had that kind of industry there as well, but again they didn't use the water power. Another big thing you had in the area, which goes back a little bit, was you had Merton priory, which was the third richest priory in the country, and the richest in Surrey, then got destroyed by Henry VIII, because they didn't have a,- they didn't have a parish community so they couldn't get turned into a parish church to get saved. But that existed here, but they made their money by selling what? Beer. (Inaudible) sell it on the ground, they had a place across the road, outside the wall, little outhouse where they used to sell all their beer. So that's where they made their money, again brewing using the water from the river. So you know, you still got that sort of tie in. Yeah, Eric can tell you a little bit, probably a little bit more technically, from the point of view of the work that went on at Fry's and Tandem Works can't ya?

Eric: Well I worked just down the road from here.

Mick: We're being taped by the way, we're bein' recorded.

Eric: That's fine. I worked just down the road from here, about a mile down the road, a company called Fry's Metals. They started off a company called (inaudible). And they took over just after the first world ward because the works that they took over was called Tandem Works and it was founded by a German company who had another place, I'm not too sure if it was Frankfurt or Stuttgart, was a similar building, that's why it's called Tandem Works. A lot of the locals thought they made bicycles because it was called Tandem Works, it was called tandem because it was a separate, or similar building to the one they had. We used to make tin-lead alloys, solder, white metals, and all bearing alloys. We did solder as well, we did multi course solder, things like that. And I worked there, well I started off there in 1972 as a draftsman. Then I was asked to take over the smelting department because, do you know what dross is? When you heat metal, you get a scum formed on the top, it's mainly oxides, they call that dross. And we used to take it off from,- a lot of people we supplied with metal used to melt it down,- white metal kits, things like that, they used to melt it down and they'd get a dross on top and they'd send it back to us, and we would smelt it back,- get metal back and then refine it, make it into other alloys. Well I was put in charge of the department,- had furnaces in there, used to smelt the dross back down to make it metal. Then it'd go to the refining shop, to refine, to get back to the alloy that they were after. And then after a while, I left the, I left the smelting shop and I was made administration manager, and that was to look after the print room and the,- we used to do a lot of printing, our own internal printing,- ordering stationery for the offices, looking after the cantines, I didn't look after them I was overall in charge. I also had another job, fork truck driving instructor. Now, in this country you have to be trained and pass an exam to be a fork truck driving instructor but you are your own examiner. Not like a car driving instructor, who doesn't do the examining, you have to be,- ministry of transport, you have to be registered as

an instructor, so you can teach the people and you can instruct 'em, then you examine them to see if they're okay. I used to do it all over the country, we had five or six branches all over the country I used to do that as well. Another job I did at the same time was what they called hygiene officer. Because it was a lead works we used to have to monitor what we put out the chimneys. And every month I used to have,- after one particular stack I used to have to go out every month and do a twenty four hour sample, and that's where my interest in the weather started because I thought I'm not going up there today if it's gunna rain tomorrow. So I got an interest in seeing what the weather was like for two or three days, I thought if it's going to be fine tomorrow I'll go up today. And I'd start the sampling one day and then go out and check it and I took it,- sample out from the filter paper into the laboratory and they would analyze what we'd bring down the stack. We also used to sample the atmosphere around the factory, this was in the days of leaded petrol. What people didn't realize, the amount of lead that was in the air from vehicles. And they used to see sometimes what was coming out of our stacks because the smoke that came with it, but they didn't realize how much lead was in the air from cars and things like that. And we used to do a sample, we had to do it very quietly, we used to do it at night when not many people were around otherwise they'd wonder what we'd be doing because we had to set up a tripod with a monitor on top of it and sample, so we did it when nobody was lookin'. And what we found out, because the samples, if they just had lead in it, we knew it wasn't ours because our samples, if they got lead in it they contain tin, cadmium, a bit of copper as well, and antimony, some of the alloys that we used to smelt down. So our emissions always contained more than one element. But cars only put out led. So we knew what was comin' out, what was ours or theirs. You'd be surprised how much lead was in the air, when leaded petrol,- people didn't know. So that's another job I used to do.

Andrew: That's actually really interesting. That's actually really cool.

Dasan: I guess that's why we turned over to you know, lead free petrol.

Andrew: Yeah.

Dasan: Makes sense, they finally realized.

Andrew: So if you want I can give you a brief overview of what we are doing for our project since you weren't here earlier. So we're from Worcester Polytechnic Institute, it's a engineering school in Massachusetts. So all three of us are engineers, and,- or, aspiring engineers.

Dasan: We consider ourselves engineers.

Andrew: Yeah. So what we're doing is we're working with the Commonside Community Development Trust if you know who they are, yeah, so Naomi, the director, wants to start an initiative, or like a project to promote engineering education in the community like the east Merton community. Because I'm sure you know there's always a shortage of engineers in the UK.

Eric: Well there wasn't in my day but (inaudible – multiple voices).

Andrew: But now there's, they're having a lot of problems with that, they're hoping to get people to get interested in the field so that's what she wants to do and we're here to kinda set the groundwork. We're here to gather data for her, we're here to talk to some of the local engineering companies to see how they would like to promote engineering, and we're here,- one of the things she would like is to kind of incorporate the local history of the area to give the project kind of a local feel to it.

Dasan: It'll give it more context-

Andrew: Yeah a local identity-

Dasan: It's more relatable to people-

Andrew: Yes-

Dasan: To see the industrial history that's been here already.

Andrew: Yeah and we were focusing on the industrial history because that, even though it's not all directly engineering, it involves a lot of interesting technology that we could, or not us specifically, but Commonside could teach to students and expose them to, which you know sparks that,- yeah like that's how I got interested in engineering, I didn't say oh you know I'll take engineering classes that's what I like. It was I went and looked at you know some industry I saw some like machinery, I saw the stuff and like this stuff's cool and then, you know, one thing led to another so,- we were interested in learning more about it that's why we came here. And also seeing how your organization kind of promotes the industry. And we were just learning about the outreach program the museum provides with the printing and describing the water mills. And we thought that was really interesting and we were trying to ask if like, if Commonside was interested would the museum be interested in kind of working together as part of an outreach program?

Eric: Oh sure they would, yeah.

Andrew: Yeah, to the,- I mean-

Eric: Well, Mick, you've discussed it with Mick-

Andrew: Yeah, he said you didn't know much about the more, the super technical aspects of it, but that's not exactly what we're looking for, we're not looking to, you know, give the students a lecture about how like, how dyes are made and how the exact technology works with physics and all that, but more of,- or more or less expose them to it, and see, and kinda say okay this is how this works, this is how it's designed and we really like the hands-on stuff you guys are doing.

Eric: Well of course I don't really know as much as Mick does about this sorta thing 'cuz I'm more on the engineering side. I've always (inaudible) an engineer. One of my last ambitions was to become a draftsman. And I became that, and I (inaudible), in fact I've achieved two of my life's ambitions, I had three. One was to be a draftsman, the other was to own a metal-turning lathe, there's one particular one in this country called a myford. Everybody using model engineering heard of a myford lathe, it's a three and a half inch lathe, about that big, and I had one of those, I've sold it now. And the other thing I wanted, BMW motorcycles and steib sidecar shaped like a zeppelin. And I always wanted a BMW and steib, I never got one of those. (inaudible – multiple voices). So I've had two of my life's ambitions.

Dasan: So I'm a, I'm a robotics engineer, and this is a little bit off topic and I don't really wanna drag this on too long but, robotics is computer science, a lot of programming, mechanical engineering, and electrical engineering. And my passions are mainly electrical engineering, and mechanical, just turning a block of metal into a product is incredible. And, I don't know, the myford lathe, how big is it, is it a desktop?

Eric: It's about that big.

Dasan: Yeah.

Eric: And it's a three and a half inch lathe. Well, you couldn't put it on a desktop you'd have to have it on a stand, the one I bought I bought from the company I worked for because they closed their laboratory down they moved up to Rochdale. And I, they were offering it for sale and I bought it from 'em. Fortunately one of the other jobs I had at the time was exhibition organizer. In addition to all these other jobs. When I, when we used to go to exhibitions I used to hire a transit van, I used to take all this stuff that we were exhibiting away to wherever it was, and I happened to have one of these vans out on hire just as they got rid of this lathe. So we got it down the steps on what

they called a stairwalker, it's like a wheelbarrow but motorized. So we got it on there and lowered it down and took it to where I live and walked it off the back of the van with a six foot scaffold plaque, and walked it into the garage and I set it up in there. And my wife complained that the noise,- and the room that it took up and so I sold it to a chap I used to meet in (inaudible). Worst job I ever did. I've still got a little model maker's lathe, but not the big one.

Dasan: I would love to own a lathe or a,- right now do know Haas the mill and lathe manufacturing company? Haas, they're German, and they build computer controlled-

Eric: I don't know

Dasan: They are fantastic and I would love to own one, they have one like this big and maybe a meter by meter platform and you can just (inaudible).

Eric: When I was an apprentice I worked for a company that used to buy and sell second hand machinery, and they had what they called a contractor's plant department. They used to hire our excavators and bulldozers and things like that. And after a while the roller path on the excavator used to wear. So they strip it all down, put it in the welding shop, weld it all up again, and they'd mount the chassis in a lathe, and it was about a nine foot chassis in the lathe, and turn the roller path out again. They had great big lathes, and overhaul hydraulic presses, and the columns on the hydraulic presses, they could turn those up on the lathe as well. They were that long, and the old chap he used to put cut on in the morning, do one cut, have his lunch, put a cut on in the afternoon, two cuts a day that was his day's work. 'Cuz they didn't go very fast, they were about seventeen, eighteen foot long, you didn't go very fast on.

Dasan: Back to topic.

Andrew: Yeah, so do you think, like using this industrial history of the area would be a good way to kinda lean towards kinda technology and engineering?

Eric: Oh sure it would, this particular area was very industrialized up until what, twenty years ago. There was a lot of industries around here.

Andrew: Okay.

Eric: There was, course it's all changed now, do you know the area at all?

Andrew: Not well.

Eric: There's a big road down the bottom it's called ransom way, it's a big bypass, before that was built there used to be a railway down there. There used to be a coal yard, there was a marshaling yard, and (inaudible) side of the railway was a road and it had lots of firms there selling bits and pieces. There was a company used to make, like Mick was saying about his (inaudible) kitchen utensils, there was a firm there. Crown Merton, they used to make kitchen utensils, it was all enamel ware though. It was still enameled with, you know, (inaudible). There was a lot of firms there, but there was another firm that used to make steel fabrications, and they did their own galvanizing. (Inaudible) sheet metal that was. There was quite a few, I can't think of 'em, off hand but there was a lot of industry in the area.

Andrew: Okay.

Eric: It's all gone now, nothing there it's gone now.

Andrew: So, do you know of any, like, kinda, you said all the industry is gone but is there any more historical kind of sites you can still visit down by the river?

Eric: Oh, there's one down the river they call it Merton Abbey Mills, and that was the mill site of Arthur Liberty, have you heard of Arthur Liberty?

Dasan: Yep.

Andrew: Yes, yep.

Eric: Well that was his site, he used to do dying and all that sort of thing down there. In fact the water wheel still exists it's still working down there.

Mick: You've got industrial sites along the river still, but none that use the river. So if you go up this way, church road, and you go,- you walked along the river, (inaudible) industrial estate you see. So there are still some businesses and industrial places there. Go down that way, you go down to willow lane, there's industries down there. I couldn't tell you exactly what they are and what's working down there, certainly don't relate to what they were fifty, hundred years ago. But certainly there are industry sites, industrial sites.

Eric: We had a site down at willow lane as well. We used to make solder wire, and used to do continuous cast bronze rods. I don't know if you've heard of-

Dasan: Extrusion (inaudible)-

Eric: Well no, we used to extrude wire, used to make, used to make brazing wire. They were copper alloys, used to make solder wire, that was two lead alloys, that was all extruded. But they also used a process that was called continuous cast. They had a pot of molten bronze or copper-

Dasan: Oh they had like a conveyer.

Eric: They used to pour it into a vertical mold, it used to come down the bottom of the mold and cool as it was coming out of the mold continuously cast. And when it got to a point they cut it off with a, either a band saw or an abrasive wheel into a length and then they'd carry on casting.

Mick: Yeah thinking about it it's quite a lot, there's weir road as well, up in Wimbledon. There's somer town still got quite a bit as well. There's still industrial sites up there, that's where I was talking about the paper people that used to be there, course they're not there but it's still industrial areas there.

Eric: Have you mentioned the (inaudible) mills Mick?

Mick: I didn't talk directly about the (inaudible) mills.

Eric: Colliers Wood, that's all (inaudible – multiple voices)

Mick: Those were the paper mills but of course that's all gone now. I'm trying to think, just following the river through, where else there is. See then you get up to, once you get into Wandsworth there isn't anything. I can't think of anything industrial-wise there is in Wandsworth anymore, 'cuz all the river up there has been turned into flats and what have you. Certainly down in the Merton bit,- the river certainly the weir road. Somer town, there are industrial buildings down there, what the industries are I couldn't tell you. I would be surprised if they're engineering companies, it really would surprise me. I do know the one at weir road is a car place, but that's the maintenance of cars, servicing.

Eric: Yeah there used to be one (inaudible – loud background noise) because my first double glazing I put in my house came from that area but whether it still exists (inaudible). It's certainly not heavy industry, we understand heavy industry.

Mick: There's an industrial building still exists bit to, more north of (inaudible) just before you get into Wandsworth. But I don't think it shows work still there. Certainly going into the Croyden end there's nothing is there?

Eric: No.

Mick: (inaudible) waddon ponds? Waddon ponds has still got industrial buildings, and there's probably industrial work takes place down there. It'd be worth investigating seeing what the businesses are. I take it that's what you were asking weren't you?

Andrew: Yeah, if there were any like-

Dasan: Historical sites-

Andrew: Yeah-

Dasan: Still around that we can visit, maybe incorporate into this project somehow.

Andrew: Yeah, incorporate it into a program or something.

Dasan: So the Merton Abbey Mills, right?

Mick: The Merton Abbey Mills is-

Dasan: They still have a functioning water wheel?

(inaudible discussion – 3-4 voices at a time)

Mick: -and it still turns the spools that they used to put cloth on to wash it in the river.

Eric: But they use that to generate power now.

Mick: Right.

Dasan: So it's hooked up to a generator essentially?

Eric: Right, and they use it to-

Mick: They use it to power-

Eric: The potter's wheel-

Mick: Potter's wheels-

Eric: They've got a little model lathe that they use, model maker's lathe they use that for turning to power the generator.

Dasan: Can you,- I assume you can go inside the building and look at all this right?

Mick: Oh yeah, yeah, (inaudible) they'll let you in.

Dasan: So is it a historical site or is it a business now?

Mick and Eric: It's a business (inaudible both voices).

Mick: It might be worth checking when the wheelhouse is open because I don't think it opens every day.

Dasan: Okay, we'll look into that then.

(inaudible multiple voices)

Mick: Oh yeah, certainly sorry, I'll give you a list, a list of places where you can see buildings.

Andrew: That works perfectly.

Mick: 'Cuz there are, from a historical point of view, what you've got in terms of buildings yeah.

(inaudible – Mick speaking from far away, other mumbling in background)

Dasan: So aside from the buildings are there any other resources, any local resources that we can use?

Mick: Merton library.

Andrew: Yeah we visited the Morden library.

Mick: You went and saw Sarah Gould did you? Up on the second floor?

Andrew: I emailed her yesterday.

Dasan: We're actually going to be talking to her probably Thursday?

Andrew: Hopefully, I'm waiting for her to get back to me but yeah, she just came back to the office yesterday, so-

Mick: Well she was in a meeting, I was with her yesterday afternoon, we spent four hours together yesterday.

Andrew: Yeah because I actually ran into one of the workers there, I forget his name I feel terrible. He mentioned,- he actually ran into me because I was sitting in the local studies section reading and obviously I look like a college, university student so he wanted to make sure I wasn't like, you know, not studying local studies. And I told him about our project and he said to contact Sarah Gould. And, so hopefully we can talk to her 'cuz he said she would be a very good resource.

Mick: Yeah, she is.

Andrew: Okay, so is there anything besides the Morden library you would recommend to visit or look into?

Dasan: Aside from these historical buildings as well.

Mick: Honeywood, honeywood museums.

Dasan: Honeywood museums.

Mick: Down in Carshalton pond. Might be worth going to talk to them, they're part of Sutton.

Eric: Yeah I don't know when they're open, I'm a member there, a friend of their museum but I don't know when they're open, we've got a program (inaudible – multiple voices).

Andrew: So do they do a lot of industry stuff too?

Mick: They might do some.

Eric: They've got a little, they've got a little bit in there-

Mick: About the river and that around there-

Eric: It's mainly about what happened around Carshalton, which is where they're located. There's bound to be a little bit of industry in there but not in the sense that you might,- well it might be I don't know.

Mick: Might be worth contacting them (inaudible – multiple voices)

Eric: Yeah they've got quite a lot of industry and (inaudible) on the pearly way, which is a bypass in Croyden, there used to be a lot of industry there. You've heard of lambretta?

Mick: I'll write down some names for you in a minute, don't worry.

Eric: Scooters?

Andrew: No, I have not.

Eric: Oh, well you've heard of vesper's scooters, well lambretta was a rival company. And they used to have a place there they used to,- have you heard the,- do you know what we talk about a bubble car?

Andrew: Yep.

Eric: Well there was Heinkel and Messerschmitt. The Heinkel was taken over by a company called Trojan, they were a van manufacturer on the pearly way. Years ago, they finished in the 50s. There's quite a lot of industry on the pearly way. Lot of foundries up that area, and what else was there? There was lambretta, and Heinkel, or Trojan as they were. Unfortunately I've got a program, not a program, a description of what the industries used to be on the pearly way years ago but that's at home. I keep it because I'm interested in industrial history, that's why I'm a member of this museum.

Mick: Trying to think what else there was. Course there are buildings around but you all recognize them as what they are now.

Andrew: Yeah like one of them, I read about the grove mill.

Mick: Yeah that's what I put down Mitcham bridge, that's Mitcham bridge you see, the grove crown, Riley's mill, brother's mill, whatever you want to call it. There was four mills there within sort of (inaudible) from each other, two of 'em on one side of the river and two on the other. So you got cuts you see.

Andrew: Do you know anything about the Holborn Industrial School?

Mick: Not a lot.

Andrew: Okay.

Mick: Not a lot, but it was there, it was down the road here.

Andrew: Does it still exist or is that gone?

Mick: No.

Andrew: That's gone?

Mick: As far as I know. Good site to have a look at. Alright, Merton Council. Want to give you some information, this is where Sarah will help you with that part. Merton memories website, that will give you a snapshot of it. Now a good set of books for ya, if you wanna know about them, you know you're welcome to come back here on a Wednesday doing your research as well guys. Good set of books, this is number fourteen. And locally within Mitcham, this is a local historian. Eric Montague.

Andrew: Yup, I've seen that series of books.

Mick: He wrote a whole lot of these books, you asked about Holborn right? So anything you wanna know about Holborn will be in here. (Inaudible) old Holborn schools. Holborn union, Holborn schools, whatever you want to know number fourteen which is this one, fourty nine and fifty four. Here you go.

Andrew: We actually found that series of books at the library, we didn't see up to fourteen though I don't believe they had that one.

Mick: They probably haven't got 'em all.

Andrew: They had up to I think six.

Mick: (Inaudible) Merton Historical Society. See they might have more information.

Eric: They must, historical, and then you said what we call them. It's not rude, it's just we, it's a play on words, instead of historical it's something else.

Mick: You can probably guess what it is. So in terms of buildings there are some, and we got some pictures of some. I'll go and get you a book, because Allison told you about some of the work I did for a project (inaudible) five years ago now. When you get older the time goes quicker boys, I'm telling you.

Appendix D

Transcript of Interview with Steve Farrow, General Manager of the TRP.

Andrew: Okay, we can begin.

Steve: Training and recruitment partnership and we're an apprentice ship and training ship provider and our funding comes through the funding skills tree which is part of the government. It's the agency they use to allocate funding. The apprenticeships we deliver are wide ranging – business admin, customer service, management, construction, fenestration, children and young people training – which is for nurseries or people working in schools. Our major forte is to deliver management training which we deliver both to local authority staff and large construction companies across the UK, not just in Merton. We've been established now for just under 20 years. Traineeships, which you may not know about, is a pre-employment program that is set up for 16 to 24 year olds. It involves pre-employment training, making a CV, interview technique training, and lining them up with a work placement with an employer.

Andrew: So what is your role specifically at TRP?

Steve: My role is general manager so all the hard work is done by all the guys next door (laughter). I do a lot of customer interface and basically making sure the money is spent appropriately, looking at all the safe guards, make sure the learners are safe, making sure we've got procedures in place, interaction with employers, and thinking of strategies of how we can increase our interaction with the local market.

Andrew: Okay! So from what we understand is TRP makes partnerships with local employers to deliver these services.

Steve: That's correct.

Andrew: How do you go about creating these partnerships?

Steve: There are a variety of ways. A lot of it is existing business, we get a lot of repeat business. Probably our best marketing tool is word of mouth. We get a lot of referrals from people that have used us. Our partners that we work closely with are local authorities, like the councils. We work very closely with the chamber of commerce – they're probably worth speaking to. Its where all the businesses go to share ideas, joint ventures. They're all representative of the businesses in the area. The Merton Chamber of Commerce is about the best one in the lot. In addition to those are the London Chamber and the Croydon Chamber, which gives us quite a good interaction. We link with pan regional organizations London working alliance where we get quite a lot of referrals through that and the management basically fills itself.

Andrew: How would you recommend Commonside go about partnering with local businesses that are private-sector?

Steve: How? Hm, I think the first thing is customer awareness. They need to let businesses know who they are, what their strategic aims are, and they need to let businesses know who they represent. So who their primary audience is or who their primary participants are. Commonside does a lot of

work with single parents, young unemployed people, but they also support their local residents. It's really Pollards Hill. High unemployment, traditional unemployment such as families with dependencies. They need to educate their clients and go to the businesses and say "this is the cohort we've got, what skills do you need, how can we help you fill that skills gap." I find it's not people need the skills, it's people need the attitude. That'll be the selling pitch. A good idea for them is to have a coffee meeting or the easiest way is to attend one of the chamber events. Have you heard of the Take One initiative?

Andrew/Dasan: No.

Steve: Right, well you'll definitely need that. The Take One initiative went to all the local employers and basically said "you need to sign up to take one apprentice a year." They smashed their target of 100 in the first year; they got about 150 people. Naomi might be able to facilitate that for you, unless she's got other things planned.

Appendix E

Transcript of Interview with Fitzroy Dawson, CEO of Merton Community Transport

Fitzroy: I'm Fitzroy Dawson, CEO of Merton Community Transport and I'm okay with it being recorded.

Dasan: We are American students from Massachusetts. We're from a school called Worcester Polytechnic Institute. We're all engineering students working with Commonside and its director, Naomi Martin, on a project entitled "Inspiring Future engineers in the Borough of Merton." It's very interesting, it's very close to our hearts, so we decided to take it on. Today, we want to help out Commonside because they need partnerships, they need funding, and help. You're not going to provide that obviously, but we'd like insight on how to get that for Commonside. We want this project to succeed. It has good motivation and ideas, but you have to take a business perspective sometimes. It's not going to succeed if it doesn't have the support it needs.

Fitzroy: That's quite interesting because one of the ladies I spoke to at #10, she was pushing for women in engineering which is very few.

Dasan: That's true in the states as well, but it's been changing.

Fitzroy: It's a big issue here because you don't get that drive from primary school/secondary school all the way through that pushes the female agenda down that engineering path where you automatically get boys being pushed in that direction. It's not sexy, it's not the kind of "in" think, so not a lot females go for it unless they got a dad in it that encouraged them or somebody mentoring and encouraging them.

I think she manages Virgin – (inaudible) – Lynn, she's an engineering manager at virgin Atlantic. I could look it up and find out who she was…I'm just trying to think, I don't take her card which is sad.

Dasan: It's not a problem, I'm sure there were so many people there.

Fitzroy: That's just one person that came to mind.

Dasan: Also, we're on a bit of a time-crunch.

Matt: We have about a week left.

Fitzroy: How long have you been here then?

Dasan: We've been here for about 2 months. Everyone went on leave for Easter and that just threw off our whole schedule.

Fitzroy: (Laughing) You don't have Easter leave over there?

Dasan: We really only get a day off.

Matt: Some places get about a week off in April.

Dasan: So, let's get down to the actual questions here: First and foremost, could you tell us a little bit about MCT and your role in it?

Fitzroy: Okay, MCT is a charitable organization. It's a company limited by guarantees. In other words, it's not for profit. It doesn't have shareholders and so forth. I had the responsibility to start it in 2000. We only had two buses them days funded from lottery and City Bridge. Talking about 300k, but we needed to use that money to employ staff, acquire vehicles and run the organization as a whole. We started with one volunteer driver and the – (inaudible) – had no depot, no nothing at all. So I was required to build the organization and the first three years were a struggle. We ended up with funding for mini-busses with a collaboration with the Police. They had an initiate that they gave me 51,000£ to buy a Mercedes mini-bus that was designed to work with perpetrators and victims of crime. The product was designed to work jointly with a minority center. They would provide the kind of mentoring and support and chat with the community and we provided transportation. They didn't get the funding to drive their end so they just said, "well, retain the bus and use it within the community provider service." So that's what we did.

From then, it was me looking for ways to obtain funding. I think one of the things I identified was after the three years where the budget was literally dying, the grants were all depleting. I was tasked to make sure I could fund raise – and I'm a terrible fund raiser. I can talk my way out of a locked safe, I'm a Houdini of conversation, and I can get out of situations. So I was confronted with the fact that if I can't grow the business, I won't have a job. For me, I have five children and a wife not working and a mortgage. I thought to myself, "Panic, Panic, Panic!" I then worked extremely hard and prayed extremely hard. One of my previous roles – I worked for 10 years in the voluntary sector as a driver for Dial-a-Ride, which is provided across London by transport for London now. So I had a lot of contacts and people I knew in that industry. So I approached them, look one of the drivers should try and get dial a ride being delivered by the community transport schemes in their own borough to subsidize the recruitment issue they were having and the cost of doing that. They wanted to meet the needs, there was more demand for them than they could service. We argued the case that if they worked with the community transport sector we could help deal with the issue – we'd be more cost effective and we already know the borough we're in. We do that as well anyways door to door transport for the elderly. Young lady from (inaudible) they had somebody from – she came over here, she was an engineer from America, but married an English man. She was working with TFL to try an develop that connectivity between the voluntary sector, community transport schemes, and TFl to see if there was any synergy in us doing work for them – delivering door to door service, the outcome of her review was there is. We were selected to provide 5 routes on a small contract, which we did for the first couple years, we did 4 and we talked to our neighbor and they did one as well. The outcome of that is it automatically put us in a position of stability because the income was being driven by a delivery of service rather than funding and grants. As long as I continued to deliver a service, I would get an income which is a stronger position to be in rather than go for fund raising. That worked well and they kept expanding it and (inaudible) we went from 5 to 10 and from 10 to 30. We're now in the middle of re-tendering. I also did some work with a framework agreement within Merton, Sutton, and Kingston. We delivered a school run (inaudible) we drove that develop and income and then grew the business from just two busses and a couple of stuff and now we've got 4 staff on the payroll and we've got about 25 vehicles now. We setup and developed the personal transport service which is very specific because (inaudible) the council wanted to drive instead of provide service for the elderly themselves all the time, they wanted to change that dynamic and keep the budget to the individual and the budget can buy the own services they required. When that agenda developed I thought, "well, why don't I focus on the individual and bespoke services for the individual" and when the individual gets the budget they will ask us to deliver it because we are a bespoken service for individuals with disability and impairment and we'll make it fit around the car scheme structure we operate on. (inaudible) and the only element is we have to charge VAT, but we structure it so it's affordable.

We do a lot of individual transportation for the council and people within the community. We've grown our excursions (inaudible) people that deal with isolation need to get out, and if they can't

get out they get depressed and go to the GP and all that and it costs the b and g loads of money but if you can get people out the house and meet other people, take them down to the coast, you know what I mean? They become happier individuals and they don't feel unwell and can deal with their aches and pains a bit better. We drive that. We do a monthly excursion to Viras coastal and places of interest for the elderly. That really helps underpin our services. Our main income stream, although we're developed and setup to do group hire, which is groups like commonside registering with us and then using the busses and pay us accordingly. But they are groups with council funds and provide services for centers such as commonside. (inaudible) but it's through the council sometimes a way of them funding organizations like commonside and others, but that's all changes. We're really trying to push the agenda out and say great, we're here and still growing and providing a service. (inaudible) I you are going to put a bid in to the lottery for funding, or to any other organization, heritage, for funding, please remember to add in transportation. If you put into your bid that you'll provide a knitting service or rekindle pottery making for the elderly. Okay we've done that, we've won the money, we're going to provide a service and half your members will say, "How are we getting to you? Are you going to provide transportation for us?" "No that wasn't in the bid" "well we can't afford to pay for a taxi or specialized vehicle to come, we'd love to but we can't afford it, so we can't be part of it." So there's an area of people they can't reach or can't meet, because one they didn't have to seek funding separately for the transportation cost or they ring me and ask if I can provide volunteers. Well, I don't go to the fuel station and get fuel for free, maintenance of a vehicle is not free. I may have a volunteer, but a running cost needs to be covered. So there has to be some charge and we've got no money, so we get no service. Because being a voluntary based organization there's still a cost of expertise and management and to maintain the vehicles we have. Sometimes they (inaudible) though we are charitable and aren't for profit there is a cost center in relation to delivering a service. So, unless we get funding to deliver it to you, you've got to get funding! It won't cost you anything, it won't cost us nothing. But a person will benefit because the cost is covered by them being in your funding application that cost is in there. And a lot of funders are looking to well, "oh well maybe they have their own bus or maybe their own form of transportation, and that's why it's not in the bid." A lot of funders say to us sometimes, a lot of organizations forget to report transportation in the bid, especially when they're catering for elderly disable people with vision impairment and so forth, then and they say you need to come to some center and people are scattered all over the borough. Because they say they're going to meet people – bridge the gap between east and the west and so forth, so then they have to find a way of getting those people in to meet the criteria of their funding they've got and to monitor that. Sometimes they fall back or they can't get the people in and so they only end up with people that who can afford other was of accessing pollards hill, and it's not the easiest place through network hubs to get to if you're elderly. That's one of the areas I'm trying to education the borough in that aspect. Sometimes it's hard because I think I'm being terrible because I should be able to do it for free, but we don't get funded by the council to do it. There's laws and overheads and costs and I've got to meet those. I'm actually trying to grow that side of the business. There are some funding I've got from (inaudible) housing to train some of their residents to drive the vehicles. They then go on to get a job and others volunteer. As we get work from other sources, we get – schools use as a lot for like – badminton competition with the next school, just maybe in the next borough. You still have to take a class of 16 kids to the next borough venue to compete and next time pick them up and bring them to yours or whatever. We work with schools in providing that middle area of transportation. Statutory, some of the disabled schools people are picked up in the morning and dropped off in the evening.

Dasan: Are these services provided by their funding?

Fitzroy: Well the council, the gov't runs schools that are statutory and aren't necessarily funded the same…

Dasan: Presumably, private schools don't require these services then.

Fitzroy: Some private schools got their own vehicles and do it themselves, but there a lot of schools hiring coaches in or busses in and have them taken to an athletic venue like crystal palace to do athletics

once a year. Another time for training and sometimes they fill a 50 or 60 seater vehicle, but they don't need another 60 seat vehicle, they only need 16 and to go at separate times. That's when we slip in and provide our service.

Dasan: So you provide the flexibility.

Fitzroy: Yeah, we provide flexibility. We're keen to work with commonside to help them in any way that transportation can be a catalyst to get funded because we can do some joint bids. We'll provide the transport, they'll provide the service. So we'll pick the people up, take them to them – sometimes that looks good in a funding bid. Again, winning contracts in relation to that, Naomi is pretty good at providing different services for her clientele.

Dasan: That's the thing though – it's all coming from the council. We're trying to help them spread out and invest in local businesses. Recently we spoke to Root7, which is a glassware distributor in the area and they want to start manufacturing, they want to move into the engineering world, they want to grow their business instead of just supplying parts and whatnot. They want to develop their own product and produce it here, in Merton. Which is fairly impressive because it's very light industrial right now and – how are they working with commonside exactly?

Matt: Volunteering.

Dasan: They're providing volunteers. Some of their members volunteer at events at commonside and that is kind of what this project wants. The engineering initiative needs volunteers, it needs an external supplier, not necessarily help from the council. It needs help from engineers and technical minded people to interest youths. It's that kind of –

Fitzroy: It needs financial input as well. Why don't you approach these private companies to take commonside on board as a chosen charity they'll support in driving that agenda? And possibly would be some of the children through this process would be ones they could employ? By the end of the day they're engineering side – because I used to be in fabricating metalwork engineering before I went into this sort of stuff. There's always an element whereby there's a lack of skills or people come through apprenticeships that get training that employers can actually employ. Rather then they come out of university with a degree and no knowledge of how to weld a bit of metal together or even cut a bit of metal properly, because end of the day it's all theory based – a lot of the stuff. Some of my children who got my degree they had to spend a year working in the environment doing a particular job for a particular company. So when they then get their degree they've got that year experience and you've got a reference as well. (inaudible) So I believe a way society could grow – why can't you invest, like giving them an award, you invest and support in some staff time, make a donation – because sometimes a company can make a donation and it comes off their taxes. It's to get them seeing the benefit for their company by doing that. You raise the profile of the company. That had that social mindset of the community they're in. Whether they could end up in the long term some of the student that have other causes the drive an element in that engineering field for their company specifically, when they finish that project they'll fund it. We'll provide the training and we'll be able to do a course that fits and when kids pass that course they'll have some knowledge for that business because you'll give us the agenda for that course. When they come out and say, "Okay great, Tom started, he's gone through the process, tom finished after a year or two years." You've funded the whole process, so then it's another way of helping apprenticeships be trained and skilled enough to (inaudible) there might be a job at the end for you and you'll be able to employ someone that has knowledge of your sector because you drive that agenda.

Dasan: We've considered that and companies seem very receptive. From the commonside perspective, not necessarily the business aspect, we want to focus on younger kids. By the time you're ready for your apprenticeship or even thinking about that –

Fitzroy: What age group?

Matt: 11 to 15.

Dasan: Possibly even younger. When you hit 16, even 15, and you're doing your options, you already know what you're going to be doing for the rest of your life or you have a very good idea. If you target kids that a bit younger – the problem right now isn't that engineering is unpopular; kids don't want to go into engineering because they have these stereotypes that it's boring, that you're going to become a technician, whatever the negative stereotypes are.

Matt: Or they're just recommended other careers over it by parents.

Dasan: Exactly.

Fitzroy: So you need to set up an engineering project to entice them, to make it sexy – not for the children, but for those who are teaching the children. At the end of the day – I've got kids and the thing about children is they pick up on things that have been made sexy, look sexy and desirable and exciting. Sometimes there are – I remember some young lady, an astrologist or whatever. She was looking at the stars and said, "I wonder what's happening in the sky..." and someone gave her a telescope in which she could see them. "If you pursue this particular cause, you could learn a whole lot about the universe." And she goes "Wow…" and it drove here to take all the maths and physics and that sort of stuff and she's at NASA now. She said that it only came to be because somebody gave her [a telescope] and then she – and encouraged her. You need mentors for these young people, you need to get people (inaudible) say to the young children, "at your age, somebody filled a soap bottle under pressure and it blew up and flew into the air. How did that happen?" and then they explain the process.

Dasan: Actually, that leads really nicely into my next question. We're trying to find these people. What you're talking about are individuals that are passionate. They need to be technically minded and they need to be successful. Those are three – that's a difficult criteria for any one person to meet. That's why we turned to engineering or industrial in the area. [They] need to be local, not necessarily within Merton, but around the area because it has to have some kind of local context

for these kids. You don't want engineering or these jobs to be a distant, far away concept that they might not be able to achieve.

Fitzroy: The mentors are the people with passion and desire that would reach to that age group are usually individuals that are on TV or on the radio. I would steer my…net wider…

Dasan: Your scope?

Fitzroy: My scope wider, rather than just Merton and engineering in Merton. There was a guy in Dragon's Den who lived in and had a business in Merton, not sure if he does any more. I would look into it because kids are fascinated with people on TV, that sort of thing. There's a (inaudible) man, a group that setup a business to empowering kids into science through magic by showing them how scientific formulas produce sparks or smoke or how does this or that happen. The actually go around schools and do demonstrations and get kids into it .I think that turns lightbulbs on in children and then they want to pursue because they want to become a scientist. That's why I think you have to make [your scope] wider. Basically (inaudible) its driven from Commonside's project, but it will drag any expert from anywhere they are to willingly talk to the children and empower them and excite them about the possibilities of engineering. At the end of the day, I don't think Merton will capture – this landmass could fit in Texas about 5 times. This is a very small country, so to find the expertise – and again it doesn't even have to be in the UK. You may find someone in the USA who'd be happy to fly over and spend time on a particular project with children of an age because you guys drove it. When you go back, you can take this knowledge with you. Say, "We're looking to take anybody who's willing to give up –"you know they could have originally left the UK and became successful in the US and have that UK link. They'll go "aw, I'd love to give back" because they've got the time to do it "which jet shall I take." They may have that power or connection. So I would broaden my scope to find the best person who will be – to come to Commonside and put on something or to have it done at different venues and bring all the kids there and I'll do the transportation, you know what I mean? (laughter) I think that is a way I would look at it if you're going to look at it if you're going to look at it from 7 upwards. My son is like 9 years old and he tells me "oh we got taken to this and we did this project and it was really good and we were all able to make this and do that and this man came from and he's so and so" just read off lists of expertise and everything else. It inspires him and if you can get them to follow that up – email so and so or go onto some blogs for kids or something that keeps their energy going. What I remember when I used to teach martial arts is the best time to capture kids is between 5 and 7 really. That timescale for me, I've got them really to understand the concept on what martial arts is about and it's not about beating people up, it's about developing self. I studied Zen Buddhism and Zen Kendo (inaudible) but that's another story. I had some awesome kids that would literally – their parents would tell me, "all they do after the session is go home and will practice for about two hours to remember the moves you taught them so when they come back next week, they can shine for you. They love performing for you. I can't get them to do anything, but you're their sensei, you're their instructor and if you set them a target, set them a task, religiously they will do it till they've mastered it and they'll come and show you and when you encourage them, they just light up." That's what you want to be done. You need that kind of person.

Dasan: So what we need is not local. What we need are philanthropists and people with charisma then?

Fitzroy: Exactly.

Dasan: I'm not sure if we'll have access to kids that young, but –

Fitzroy: Well at the end of the day you can set the age where the project allows it. Whatever age they are doesn't matter. I was inspired by #10 and I'm older than the guy that's prime minister, so for me it's just being able to rub shoulders with people of success. It breeds success. There's an energy there. Sometimes people say to me "you're over confident and you're too passionate!" and I tell them forgive me for those sins, I love them myself and I can't – it doesn't make, you know?

Dasan: (laughter) Who says that? Nobody says that.

Fitzroy: They do!

Dasan: You can't enjoy or love something too much!

Fitzroy: I've had that said about me because that's how I operate. Some people are just a glass half empty all the time and they don't like being around people that are glass half full. It's the same level, but mine is going to be filled. Theirs is half empty and it's going to be empty, so they're negative but really they are the same level!

Dasan: Do you have any tips on finding these kind of people?

Fitzroy: Google first.

Dasan: Google? Just straight Google.

Fitzroy: Just throw it out there, it's what I do. Even my son picks up the phone and says "Google, I'm doing my homework, can you help me?" I tell him hey! Don't let google give you the answers! He'll never learn anything. I reckon that – I don't have anybody that I know specifically. I could ask because I do rub shoulders with a few people who are wealthy. I belong to the Rolls Royce and Bentley enthusiast association and I don't have a Rolls Royce or a Bentley, but I just like being with successful people. I go to the events and they turn up with these wonderful classic cars and I'm surrounded by businessmen. We talk and maybe I'll get a classic one and bus it in to keep networking with these people. They are a national association, they're all across the world. There's even some in America. But I think you need to target the companies and directors and find out – between you and Naomi, you can put together one of these letters and I'll give you an example. Let's say I want to meet President Obama. Now how will you be able to speak with President Obama? Do the research of the processes required and you'll find someone in the chain that you can write to and say "this is my greatest wish, it's in my bucket before I die, and I'd love to be able to speak to President Obama. Also, it's linked to a project encouraging young people blah blah blah." You get some sob story and it goes through all the stages until you get an audience with President Obama. So, look into the top people you want to relate to and then find out who the secretary is, whoever it is and see if you can go through the process. Find out what their hobby is! You can go in through another route. Does he play golf? Find out where he goes and plays and send a letter to his golf club. Contact his golf club and ask them to pass a letter on with some sob story attached. Maybe you share a love of dogs. Find the connection that would give you the engagement you want so you can actually say I'm supporting a charity and I'd really like to encourage young people to get involved in engineering and you're one of the greatest

engineers that I know in this field. Once you get to one person, they will know nearly everybody else on that level because they engage people at that level.

Dasan: So even if I can't get "them," as long as I can talk to them, I can get someone –

Fitzroy: Exactly, that's how I see it.

Dasan: That's um…you make networking sound so simple!

Fitzroy: But but it's been shown and done at the events I've been to. Its empowered me and I thought wow. At the savoy hotel they have a lot of individuals that meet up. It's called the macardo club or something and they network with each other and they basically have a notice board and everybody in the group will put up notices like "I'm looking to get a nice yacht at a good price" and put up their number. So the next person will go up and put "I'm looking to find a nice villa in the south of France" and so on. Then everybody looks at the board and knows somebody that can help and trade information and that's how they network. And this is the guy that runs it!

Dasan: That is a powerful business card!

Fitzroy: It is a powerful card right there. So if you want to take a picture of that card, you can contact him and say this is what I'm doing, I met with a friend of yours, Fitzroy Dawson, and he said you'd be a good person to ask.

Dasan: "Do you have any philanthropic, kind, engineering minded people that could help out at our small charity to inspire youths?"

Fitzroy: That's it. It's that easy.

Appendix F

Guidelines for Interviews with Rob Innis from Root7

Preamble
(After introductions)

We are students from Worcester Polytechnic Institute, which is an engineering university in Massachusetts. We're working with Commonside and its director, Naomi Martin, on a new project entitled "Inspiring Future Engineers in the Borough of Merton."

Interview Questions

1. Would you say that (Insert Company) currently needs more engineers or technicians?
    1. If so, what steps have been taken to reach this?
2. What do you think about the engineering community within London?
    a. For example, is this community lacking/expanding/fully developed?
3. What kind of relationship does (insert company) have with the local community?
    . *(Explanation)* Do you have an outreach program, or sponsor a sport team, or do something that lets the community recognize (insert company)?

Andrew: *Describe the project*

Discussion Questions

1. How do you think (Insert Company) can benefit this project?
2. How do you think Commonside can benefit (insert company)?
    a. *(Examples)* What other charities have done: host a job fair, marketing at community events, involvement in outreach programs
3. Has your organization partnered or considered a partnership with a charity organization before?
    . If so, could you elaborate on the matter?

Transcript of Interview with Rob Innis from Root7

Dasan: What exactly is your position at Root7.

Rob: Root7 is one of our businesses. I was already talking to you about our water business, that's our core and we've been doing that for a long time, about 15 years or so, Root7 is a distribution company. We distribute homeware products into the high streets. It's a lot of American brands that we represent in the UK.

Dasan: What other organizations are in this building?

Rob: We've got a movers company, a catering company, and then the water company. So that's what we do, we sell stuff (laughter).

Dasan: So what's your role in all of this?

Rob: I'm the managing director.

Dasan: Perfect, we're talking to the right person. Would you say Root7, assuming that has the most engineering qualities –

Rob: Yup that's right.

Dasan: Would you say Root7 needs more engineers? Or maybe technicians?

Rob: So our direct involvement in this is very limited, but yes. In essence, we could do with more. We've got a new guy employed over here and he's a product designer. He's going out to China next week to meet with factories to try and get our manufacturing moving forward. Now I wouldn't say I would want to manufacture stuff in Merton because that's going to cost me too much money, but to have the relevant skills to talk to manufacturers and say what actually goes into making a product is useful to us. That's what our new recruit is showing us, we don't know engineering. I don't know materials and tooling. We're about what we're going to sell not really what we're going to make.

Dasan: What steps have you taken to get more engineers then? Obviously you just hired a new guy.

Rob: We have not done much else from that. We have engineers in the sense of tech guys that maintain our equipment in the fields. They haven't got degrees, they're technicians with bags of tools really.

Dasan: What kind of relationship does Root7 have with the community? Do you have an outreach program or sponsor a football team?

Rob: We're involved with Commonside actually, but more locally – just bits and bobs. We don't really have a specific program. We do a few events and work with other industrial estates, but really bits and bobs. Small catering and stuff like that.

Dasan: Great, everything counts. So onto some more discussion type questions. How do you think Root7 could help Commonside's project?

Rob: I'm not sure I entirely understand the point of the project. What are you trying to achieve?

Andrew: Want me to explain?

Dasan: Sure thing.

Andrew: The main point of the project is to promote engineering and technical skill in local schools to hopefully influence students to go into that field. It doesn't need to be purely engineering, it could be – what you were talking about – practical skills.

Rob: I do give value to those practical skills. A lot of the new guys don't really have that, like an understanding of how things work. I do think there's more value in young people learning these skills.

Dasan: We've actually had a survey and a pretty sample of kids, but most of them say maths and science is important, but they don't want to go into engineering. That's what we're trying to do with this project. Make it relatable and interesting and show how those things can be practical. So how do you think Root7 could help with that?

Rob: In reality, knowing where a product goes from the supplier to your shelves to the customers pocket or whatever – in the past we've had interns mainly because it's cheap labor, but for the young guys it's been useful to see what the endpoint of the whole process is. We could show the business side of engineering.

Dasan: Cool. How do you think Commonside could give back to make your efforts worthwhile?

Rob: I don't know really, I don't know. I suppose its connections and fitting the right people together. I don't think there's any real defined value in – you know we wouldn't work with the community for commercial gain. I'm not having this conversation because I thought there would be commercial value in it (laughter). I'm doing it to be nice and I buy into it. Into the value of the whole charity and giving back to the community idea. How do you view yourself as a business? You're stepping out into the community, not waiting for things to come to you.

Andrew: So to get your name out there and let people know who you are?

Rob: Yeah, it's all useful stuff. Not to say it's the point of it in the first place, but it's all part of it. Building a culture of how you operate as a business is important and this is a good way of doing it. That's the value we get, that's the value from our side of things.

Appendix G

Guidelines for Interview with Representatives from Viridor

Preamble
(After introductions)

We are students from Worcester Polytechnic Institute, which is an engineering university in Massachusetts. We're working with Commonside and its director, Naomi Martin, on a new project entitled "Inspiring Future Engineers in the Borough of Merton."

Interview Questions

1. Would you say that (Insert Company) currently needs more engineers or technicians?
    1. If so, what steps have been taken to reach this?
2. What do you think about the engineering community within London?
    b. For example, is this community lacking/expanding/fully developed?
3. What kind of relationship does (insert company) have with the local community?
    c. *(Explanation)* Do you have an outreach program, or sponsor a sport team, or do something that lets the community recognize (insert company)?

Andrew: *Describe the project*

Discussion Questions

4. How do you think (Insert Company) can benefit this project?
5. How do you think Commonside can benefit (insert company)?
    a. *(Examples)* What other charities have done: host a job fair, marketing at community events, involvement in outreach programs
6. Has your organization partnered or considered a partnership with a charity organization before?
    . If so, could you elaborate on the matter?

Transcript from Interview with Viridor Interview

Viridor did not consent to a recorded interview. Our notes from the interview are below.

#1

- Viridor absolutely needs more engineers. The area doesn't have much in the line of engineering, just basic technicians
- Apprenticeships sometimes don't cut it
- Too "much" variety of degrees in the UK

#2

- Commitment to take on apprenticeships
- Large outreach program 11 y/o to 18 yo
- Graduate management program. Civil, mech-e, processes, gives students business experience to 18-21 y/o grads

#3

- Local education work about the sit
- Charitable giving/funding for projects
- Local employment
- Community liaison meeting to discuss development and raise issues

- Funding project just started - benefits the local community, not specific

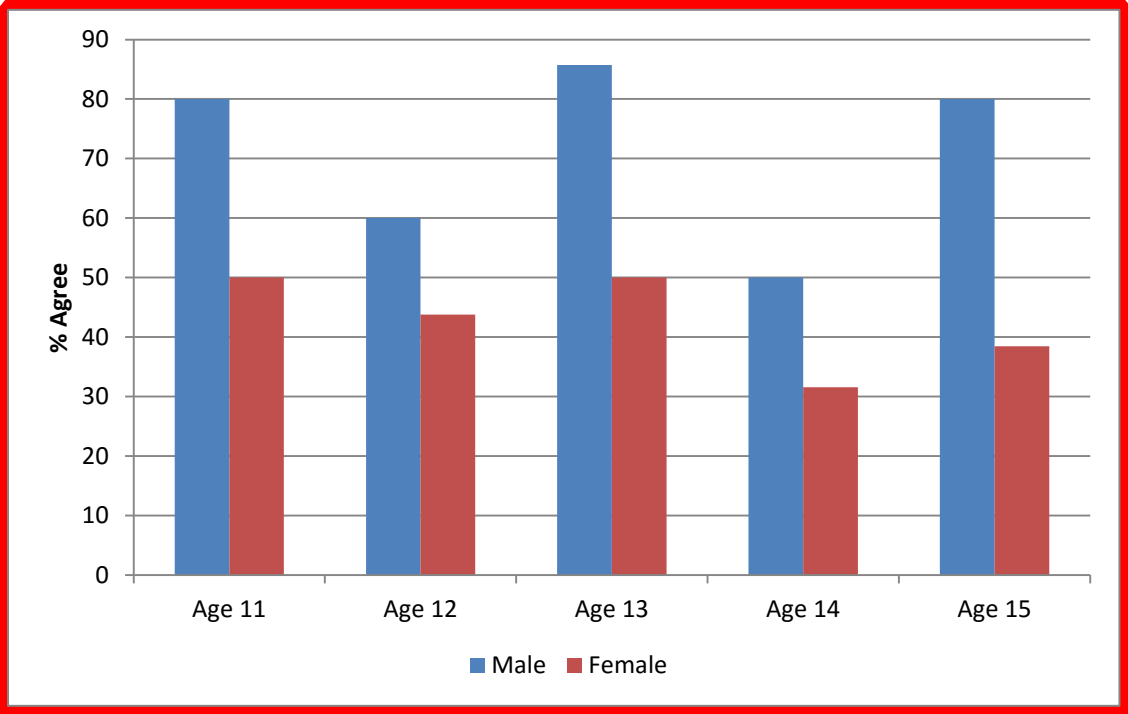
#4

- Outreach: will start when the facility is operational
- Educational center, tour
- Commonside provides the networking potential, schools, and possible apprenticeships

Appendix H

How Does Interest in Engineering Change with Age and Gender?

As part of our survey we wanted to know how interest in engineering varied with age. To display these data we sorted the responses of "I am interested in learning more about engineering" and "I would be interested in participating in afterschool activities that teach me about science or engineering" by age. Analyzing this relationship will help determine at which age(s) to focus outreach programs.

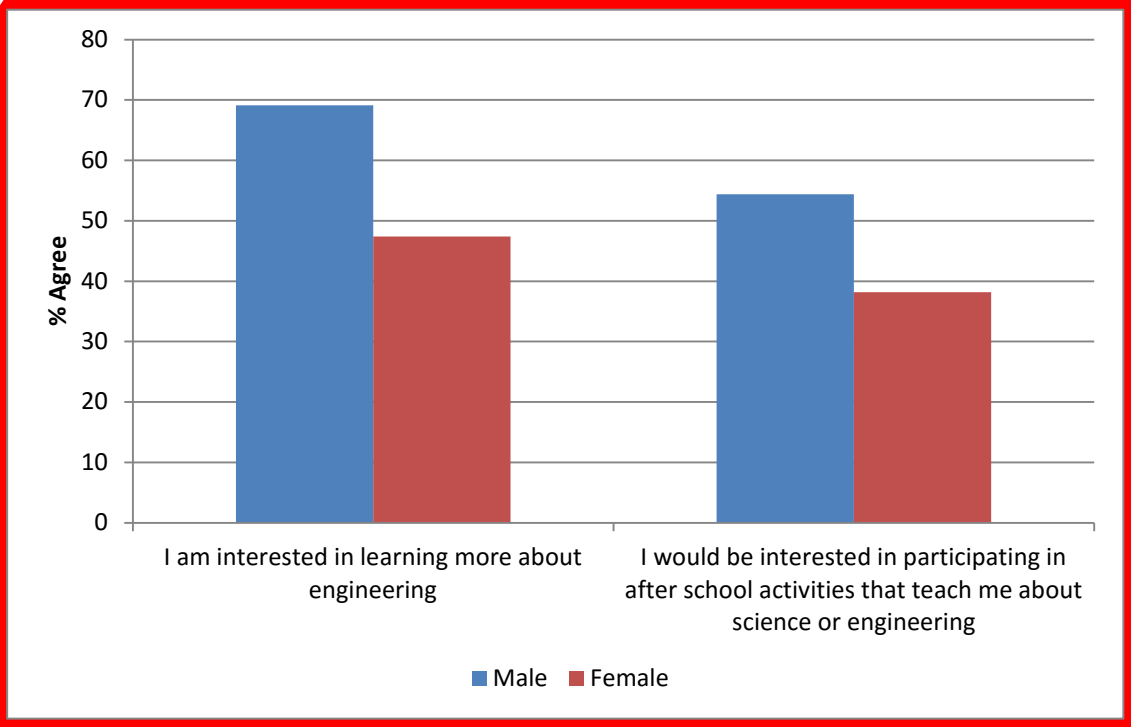


Students Interested in Learning More about Engineering

We determined that there is no positive or negative correlation between age and student interest in learning more about engineering between the ages of 11 and 15 years old. However, female students were much less interested in learning more about engineering than male students in every age group.

How Does Interest in Engineering Change with Age and Gender?

As part of our survey we wanted to know if interest in engineering differed between boys and girls. To display these data we sorted the responses of "I am interested in learning more about engineering" and "I would be interested in participating in after school activities that teach me about science or engineering" by gender. Analyzing this relationship will help determine if schools and/or outreach organizers should create programs catered towards a specific gender.

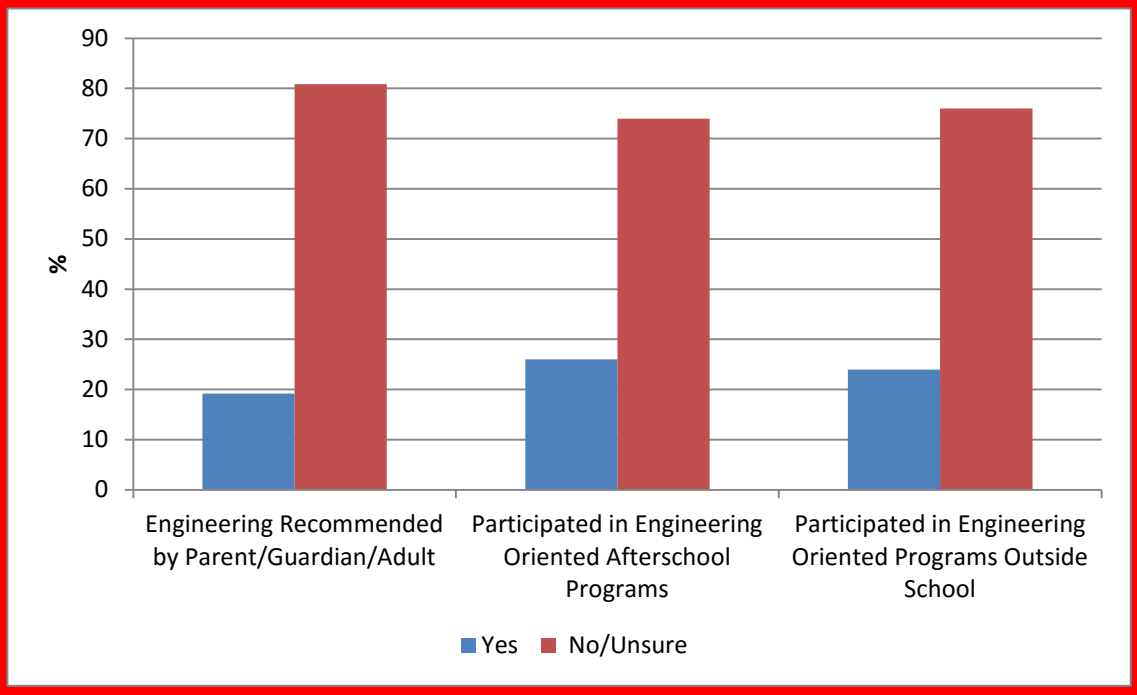


Student Interest in Engineering by Gender

From these data we determined that compared to boys, girls have a significantly lower interest in learning about engineering and participating in engineering related activities. To help bridge the gap between genders we believe that in addition to running outreach programs for all students, program organizers should consider running programs designed specifically for girls.

Have Students Learned about Engineering Outside of Class?

To answer this question, we asked students if prior to taking this survey, they had participated in an engineering oriented program/activity either during an afterschool program or outside of school. We also asked students if they had ever discussed pursuing an engineering career with a parent, guardian, or other adult.

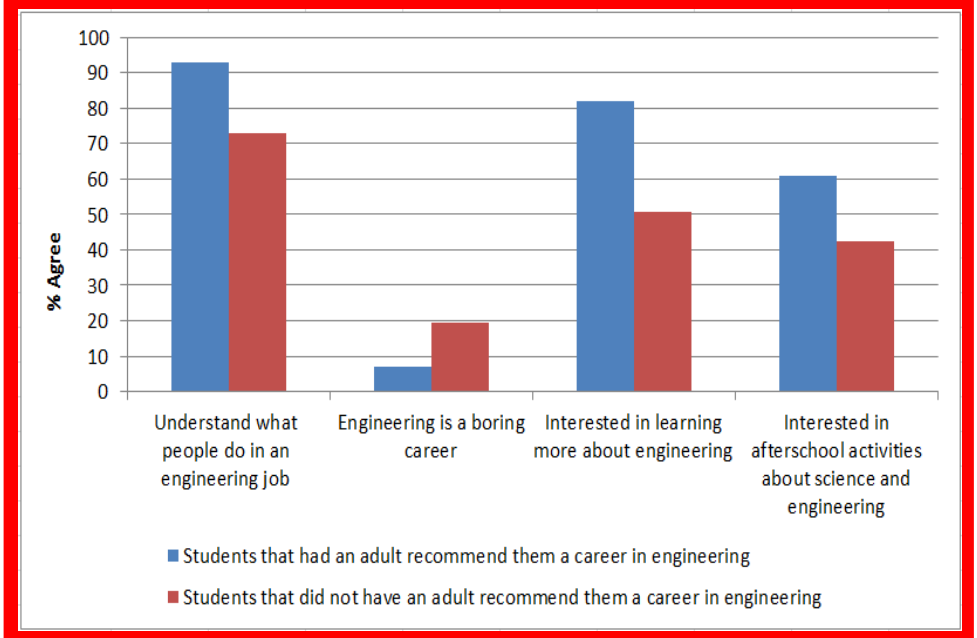


Percentage of Students Learning Engineering Skills Outside the Classroom

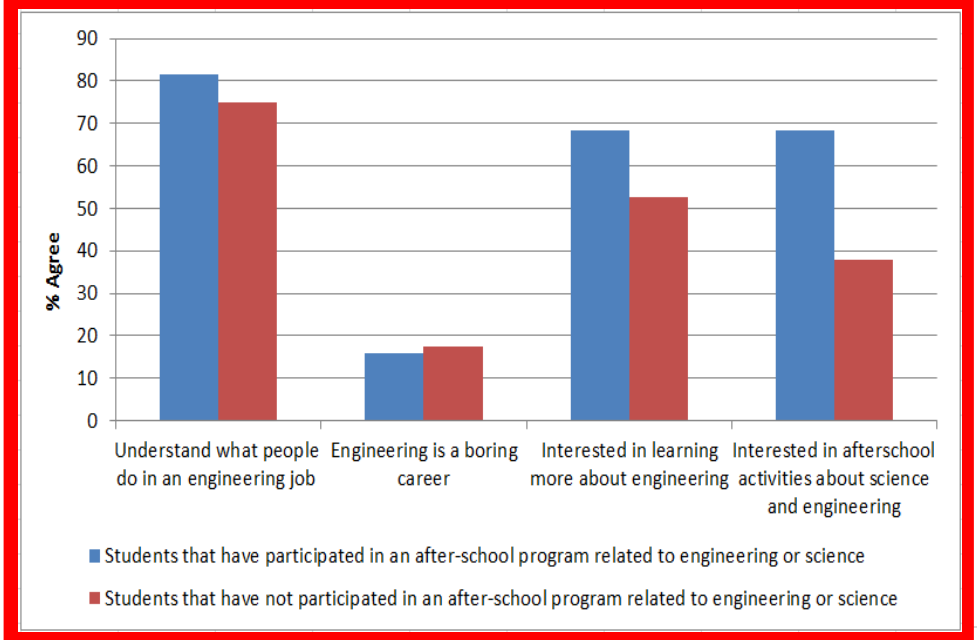
Excluding the material covered during scheduled class time, these results show that only a small percentage of students at St. Mark's Academy have participated in engineering related activities or programs. In addition, only a fraction of students have discussed the field of engineering with a parent, guardian, or other adult.

Does Outside Influence Increase Interest in Engineering?

While a large majority of students have never learned about engineering outside the classroom, we wanted to know whether the students who answered "Yes" to any of the three questions had a greater interest and clearer understanding of engineering compared to the students who answered "No/Unsure" to all three questions.



Difference in Student Interest in Engineering When Recommended by Parent/Guardian/Adult vs When Not Recommended



Difference in Student Interest in Engineering Having Participated in Engineering-Related After-School Activities vs Not Having Participated

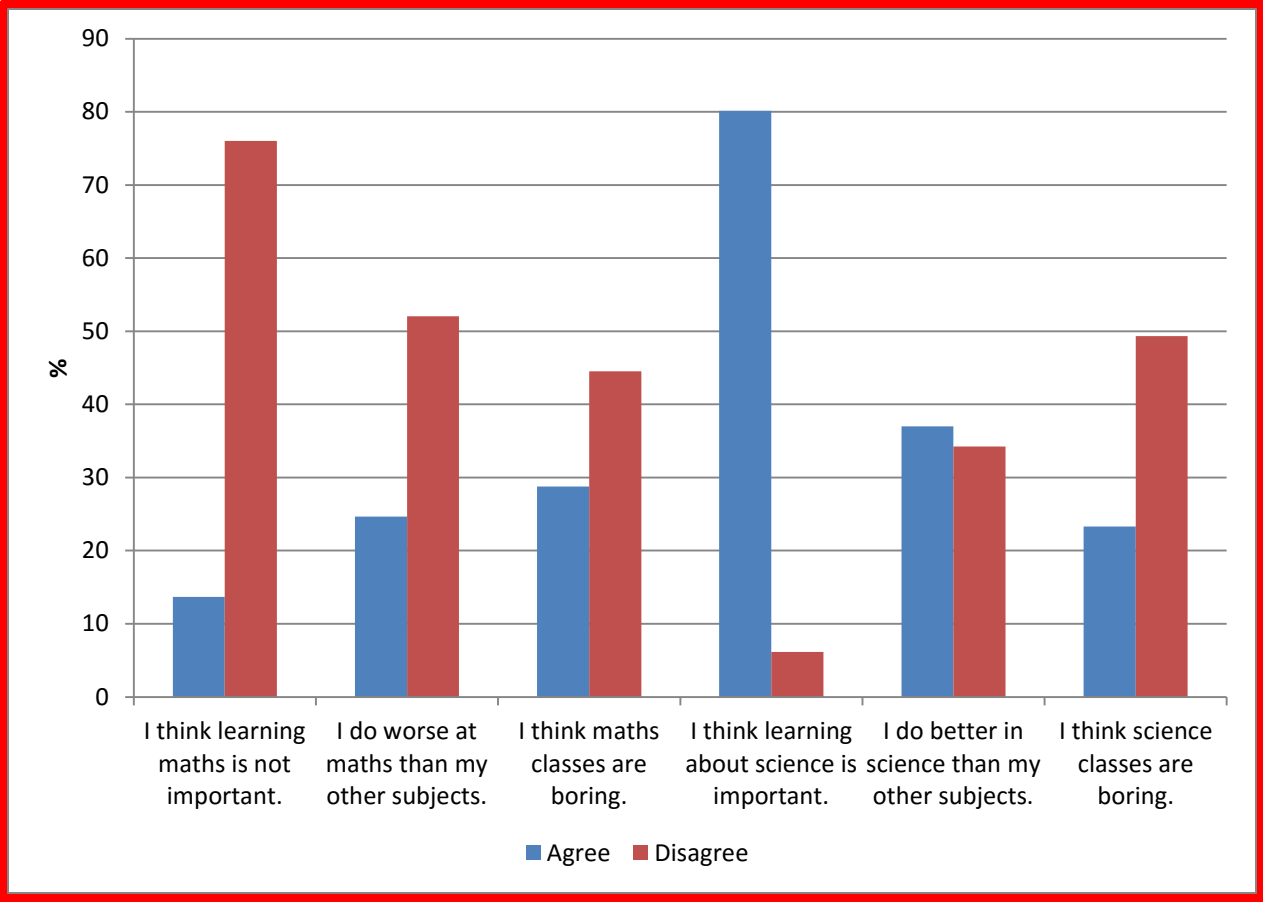
According to the two figures on the left, students who have been exposed to engineering outside the classroom have a signifcantly greater interest in the subject than students who have not participated in any engineering related activities.

These data indicate that engineering outreach programs are an effective means of increasing student interest in engineering.

Based on these results, if schools or outside orgranizations were to organize outreach programs, we believe these programs would produce a similar outcome.

How do Students Feel about Science and Maths?

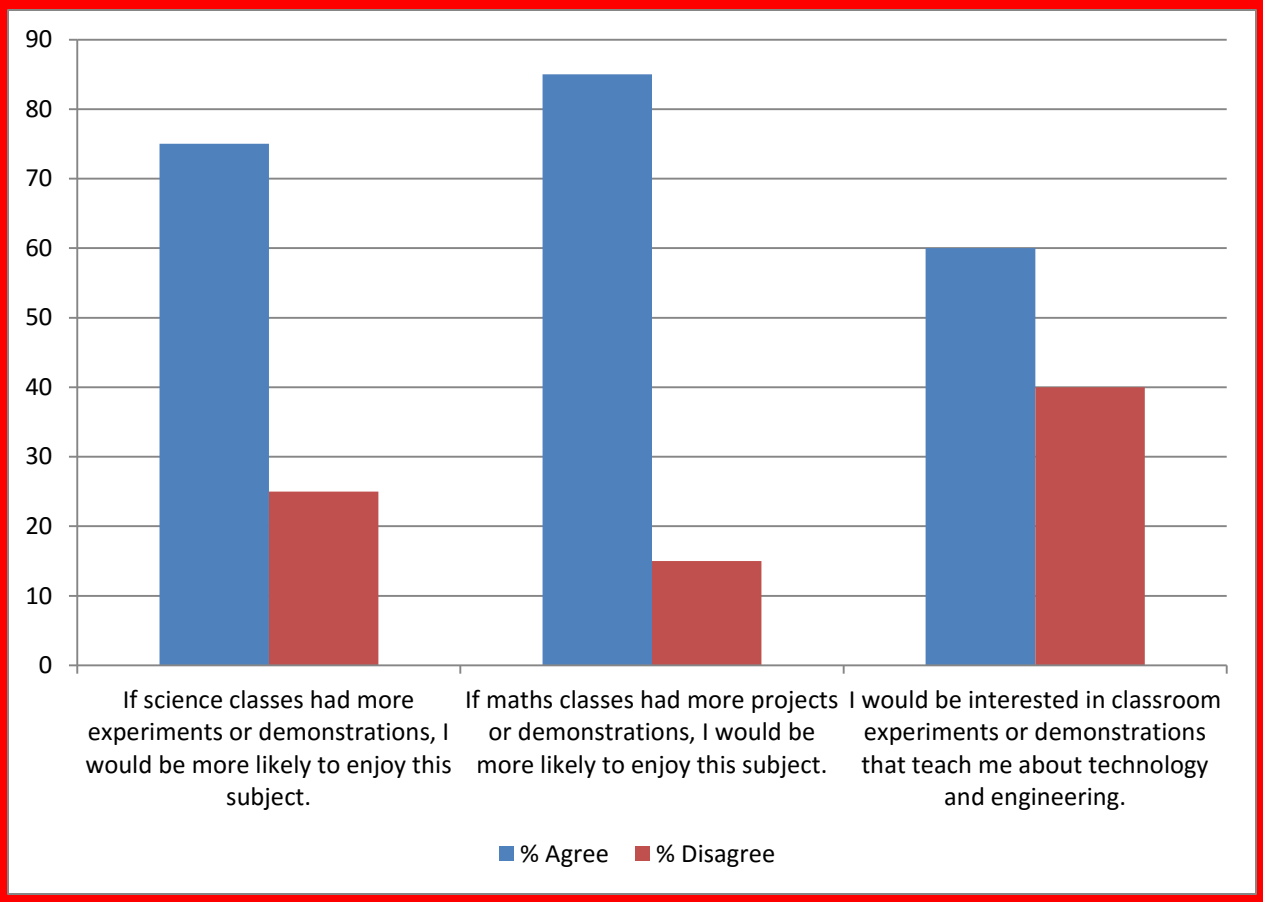
Engineering is the use of science and maths to solve problems. Students that pursue a career in engineering do not only have a strong understanding of these subjects; they also are interested in studying them. Since enjoyment from science and maths is a major factor in why students choose engineering or a related career, we decided to determine what the students' opinions on these subjects are and if additional hands-on activities will increase class participation.



Student Opinions of and Performance in Maths and Science

From our data we determined that most students believe in the importance of science and maths, and do not believe that these classes are boring.

As mentioned previously, in addition to determining the students' opinion on science and maths we also wanted to determine whether the reason why students think science and maths classes are boring is due to lack of interest in the subject or if it is due to lack of hands-on, interactive experiments.



Student Opinions on Hands-On Activities during Classes

An overwhelming number of students agree that if science and maths classes involved additional demonstrations or experiments they would be more interested in said subjects.

These data support the conclusion that the reason why students are bored during maths and science classes may not be due to the subject matter, but may be due to the class itself. In addition, in class experiments provide students with an understanding of the practical side of maths and science, showing students how these skills are used in the real world.

What Do Students want to be When They Grow Up?

Using a list of common career and job fields, we asked students to tell us which career path(s) they hope to follow once they finish their education.

We asked students to classify the jobs or careers they prefer as "Ideal" or "Expected" and classify the jobs they do not prefer as "Tolerated" or "Rejected". The definition of each classification is provided below.

IDEAL

A job the student would most like to do.

EXPECTED

A job the student feels they will most likely have after finishing their education.

TOLERABLE

A job the student would be willing to take this is still acceptable.

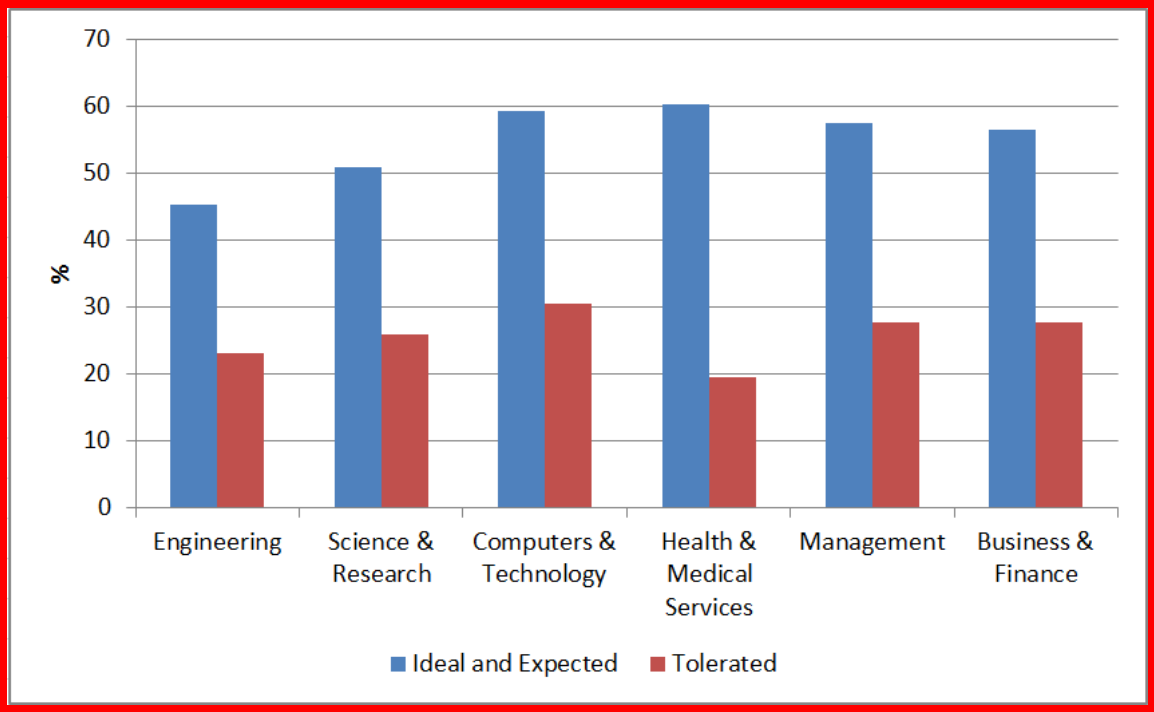
REJECTED

A job the student would absolutely not prefer doing.

We encouraged students to put multiple jobs in the same category, if applicable.

The figure below displays the results from the "career aspirations" question on the survey given to 138 students from St. Mark's Academy.

In the graph we show the results from our two main areas of interest; Engineering and Computers & Technology, in addition to providing results from the most popular career choices among students.



Career Aspirations of St. Mark's Academy Students Ages 11 to 15

From this survey we determined that while a significant number of students from the St. Mark's Academy are interested in becoming engineers, most students would prefer working in the health services, management, business, or finance. We also determined that nearly 60% of students at the St. Mark's Academy are interested in pursuing careers in computers and technology.

Appendix I

Section 1

The following pages contain the program description and outline for:

Fundamentals of Water Power

Fundamentals of Water Power

What is the Local History Behind this Program?

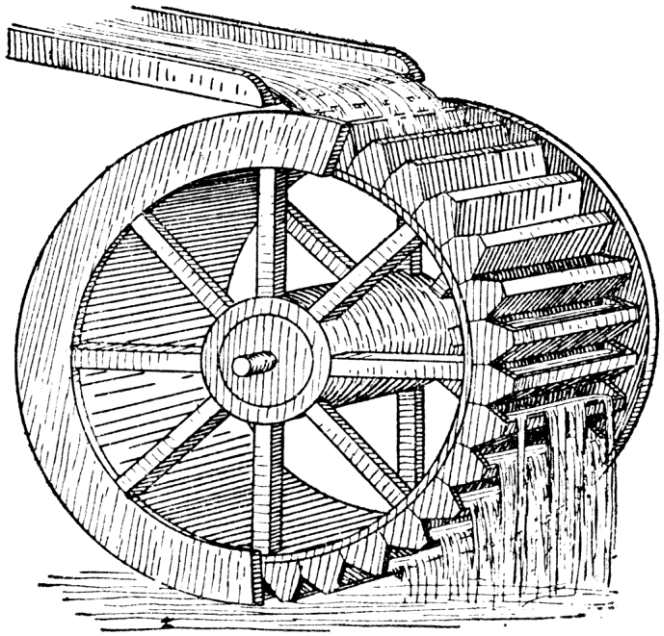
(www.merton.gov.uk)

Merton Abbey Mills was a textile factory located in East Merton, which utilized the running water from the River Wandle to power its mills. In 1881 William Morris bought the mills and converted it from a silk factory to a textile printing mill. William Morris was a textile designer, poet, and novelist famous throughout England for his wallpaper, fabric, and stained glass designs. The factory operated as a textile printing mill from 1881 until the 1980s. While most of the mills that lined the River Wandle during the industrial era have either been destroyed or repurposed, the Merton Abbey Mills is one of the only mills from the 19th century still in operation, providing visitors with a glimpse into the industrial era of London. While the Merton Abbey Mills is no longer a printing mill, the preserved buildings house an artisan market. What makes Merton Abbey Mills unique compared to the other remaining mills along the River Wandle is the functional waterwheel which is still used to power the machinery inside the mill (M. Taylor, personal communication, 6 April 2016).

What Will Participants Do During This Program?

(www.merton.gov.uk)

Using the waterwheel in the historical Merton Abbey Mills as a tool, the purpose of this program is to teach students the basics about the water power used to power the mills along the river. This program contains two parts; in the first part of this program students will construct a simple miniature water wheel using balsa wood and cardboard. To demonstrate how this wheel generates power, students will place their wheel in a channel of flowing water, use the spinning motion of the wheel to power a small hand-crank generator, and use the electricity from the generator to power a lightbulb. In the second part of the program, students will see a water wheel in a real-life application. Utilizing the outreach program conducted by the volunteers from the Wandle Industrial Museum, students will tour the Merton Abbey Mills and learn how the water wheel provides power for the machinery in the mill.



(etc.usf.edu)

What Will Participants Learn From This Program?

By observing how the spinning motion of the simple mechanical wheel powers the electrical lightbulb students will learn how to relate mechanical work to electrical power.

In addition, during the Merton Abbey Mills tour by the Wandle Industrial Museum volunteers students will learn how the material they learned during the program relates to an actual application. By visiting the mills and touring the water wheel, students can see how running water powers all the machines in the mill.

What are the Importance of These Skills and This Information?

Every day, students witness the benefits of the conversion of mechanical energy to electrical energy and vice versa, but may not understand the technology. By exposing students to this topic during the program, they will start to recognize the relationship between mechanical and electrical energy throughout everyday life. This relationship will help students begin to understand much of the appliances and technology they see every day.

Exposing students to applications of the technology and concepts they learn is essential to solidifying their understanding of the topics. In most classes, students may learn maths, science, or simple technology but rarely get a chance to see these concepts in practical applications. If students learn the concepts but not the applications, they may believe these concepts are not important and forget about them.

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Outline and Suggested Timeline

1. Introduce the history of the Merton Abbey Mills and provide basic information about the water wheels. (10 min)
2. Introduce the activity and hand out materials. (5 min)
3. Assist students in cutting two circular pieces of cardboard (15 min)
4. Assist students in cutting about eight paddles out of foam board (20 min)
5. Glue each paddle to one side of the cardboard, each angled 40 degrees from the previous paddle. (15 min)
6. Glue the other circular piece of cardboard on the paddles and run a dowel through the two circular pieces. (10 min)
7. Place the waterwheel on a stand above the empty water channel. (5 min)
8. Connect the handle of the crank generator/lightbulb about a few inches from the center of the water wheel. (2 min)
9. Run water through the channel using a hose. (2 min)
10. Observe as the water wheel spins the crank and powers the lightbulb. (2 min)
11. After each student has completed the task, embark on the guided tour to the Merton Abbey Mills to a see a full sized water wheel and point out the similarities between the experiment and the actual water wheel. (2 hr)

Materials

- Cardboard
- Foam board
- Dowel
- Water channel and hose
- Cutting tools
- Glue

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Brief Overview of the Science in this Program

The water force from the flowing water pushes the flaps and spins the water wheel. The spinning motion from the wheel causes a magnet wrapped in wire inside the crank generator to move back and forth. This back and forth motion induces an electrical current in the wire, which provides electricity to the lightbulb.

Recommended Participants

Due to the simplicity of the tasks, we recommend that this program be marketed towards are younger audience, primarily 11 to 13 year old students.

Possible Issues

A possible issue with the program will most likely involve the proper configuration of the water channel and the water wheel. We recommend before administering this program, volunteers should run extensive testing involving multiple experimental set-ups to determine how to run the experiment efficiently and without problem.

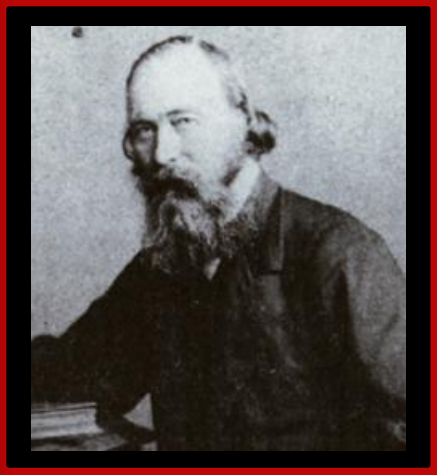
Section 2

The following pages contain the program description and outline for:

Railway Bridge Design Contest

Railway Bridge Design Contest

What is the Local History Behind this Program?



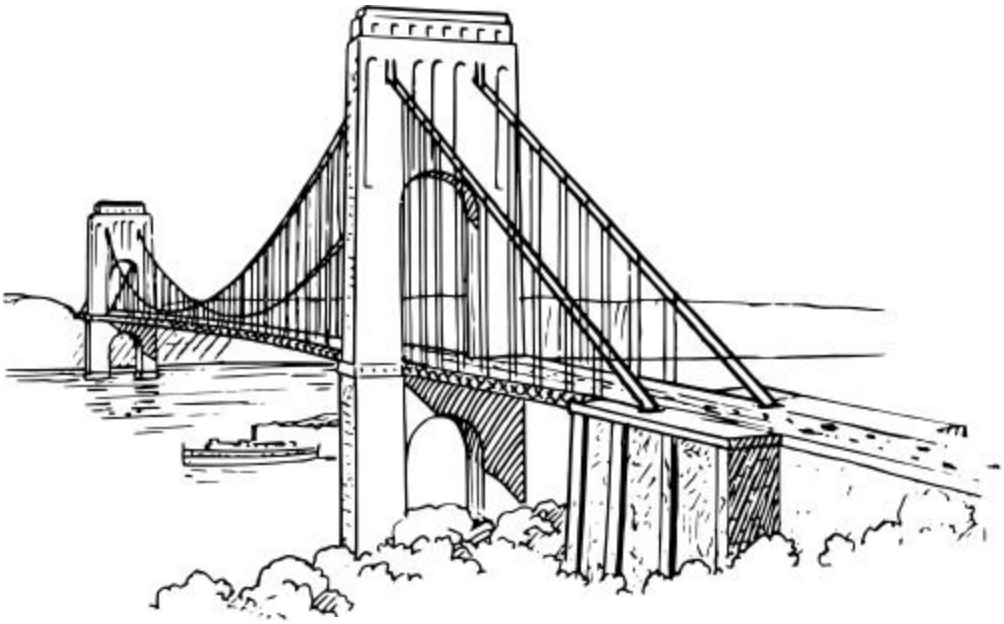
(en.wikipedia.org)

While he was born in Scotland, Sir James Brunlees (1816-1892) was a well-known resident of Wimbledon, located in the Borough of Merton. Throughout his career as a civil engineer, Brunlees built several railway bridges in England, Scotland, New Zealand, and even a bridge in Brazil. His most important piece of work was the railway across the Morecambe Bay. This bridge was built to provide an essential link between the railways in Northern England to the railways in Southern England. While the total railway was only 19 miles, 10 of those miles were across embankments and tidal waters consisting of sand from 30 to 70 feet deep; this deep sand made the project very difficult. Despite this challenge, five years after Brunlees took over the role of construction engineer, he completed the bridge and the railway opened the line. His work on this bridge earned him praise from esteemed engineers and many others used his techniques to build bridges, viaducts, and piers (Grace's Guide, 2015).

What Will Participants Do During This Program?

(designday.msu.edu)

During this competitive program, students will design, build, and test a railway truss bridge similar to the bridges created by James Brunlees. Prior to beginning the program students will learn about James Brunlees, his work, and about the basics of designing a truss bridge. Before starting the competition, the program proctor will provide each participant with a set amount of "Pounds" which participants will use to "buy" materials such as glue, straws, spaghetti, tape, etc. to build their bridge. Students will compete to decide which bridge holds the most total weight before breaking and which bridge has the highest weight supported to cost ratio. As a way to involve parents in the program the proctor may make the contest either parents versus students or have student-parent teams compete against each other.



(www.clipartpanda.com)

What Skills Will Participants Learn From This Program?

In this program students will learn the basics of creative design and resource management. By incorporating a competition into a bridge building program, participants not only learn about how to construct a bridge, they will also think critically about optimizing their design. Participants are not trying just to construct a bridge; they are trying to construct the best bridge, so they must determine the best way to approach their design and the appropriate methods for the construction of their bridge. By adding the aspect of providing currency to participants, students will learn how to construct their bridge with minimal materials and how to determine which material is best for each application.

What is the Importance of These Skills?

Creative design is a very important part of the engineering field, as part of the engineer's job description is to innovate new ways to accomplish tasks in their respective fields. In a more general sense, creative design also encourages students to think of innovative solutions when approaching a problem. These skills will help students create innovative solutions to a variety of problems in a variety of jobs.

In the business world projects have limitations and budgets. Once students enter the workforce they will have to consider cost in nearly everything they do. By teaching students how to factor cost into their designs, they will be prepared to work effectively under budget constraints.

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Outline and Suggested Timeline

1. **Introduce the history and describe the activity to the participants. (10 min)**
2. **Split the participants into groups. (1-2 min)**
3. **Tell the groups how much each material costs, give them their budgets, and have them discuss their plan before gathering materials. (5 min)**
4. **Let the teams purchase their materials with their imaginary budgets and build their bridges. (25 min)**
5. **Test each bridge by placing it over a gap of 15 cm, placing a cup on them, and placing metal washers into the cup one-by-one until the bridge collapses. (10 min)**
6. **Determine which bridge held the most weight, which bridge had the best cost to weight held ratio, and declare the winners. (5 min)**

Materials and Suggested Prices

- **Straw (5 GBP, strong bridge building material)**
- **Spaghetti (1 GBP, weak bridge building material)**
- **2cm of tape (5 GBP, holds materials together very well)**

Students will start with 50 GBP

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Brief Overview of the Science in this Program

When a force is applied to directly beam it must support the entirety of that weight without breaking. If beams are configured in a truss, or triangle, the weight is distributed and each bar will support less weight. Civil Engineers use trusses to minimize the weight on each steel beam to prevent them from breaking.

Recommended Participants and Groups

Since this program consists of very simple construction and concepts, this program is designed for students aged eight to twelve years old. Since this program is contest, we also recommend parents join to compete against and assist their children. Groups should consist of two to four members and can be parents paired with students or groups of only parents and only students. Pairing younger groups of students with their parents will help keep the students on-task. Having older students compete against their parents will give them additional motivation to win the competition. Students whose parents cannot attend can still participate and be placed into any group.

Possible Issues

If a student's parent is not able to attend or participate in the activity we recommend that this student work with another group of students or partner with a program assistant.

Section 3

The following pages contain the program description and outline for:

Railway Bridge Design, Construction, and Testing

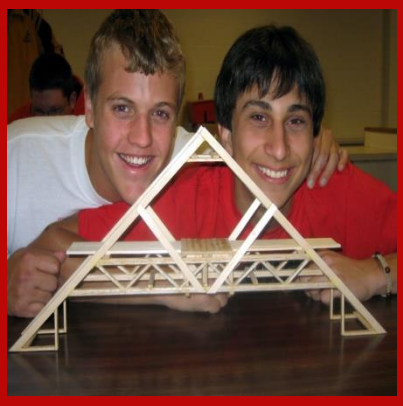
Railway Bridge Design, Construction, and Testing

What is the Local History Behind this Program?

(en.wikipedia.org)

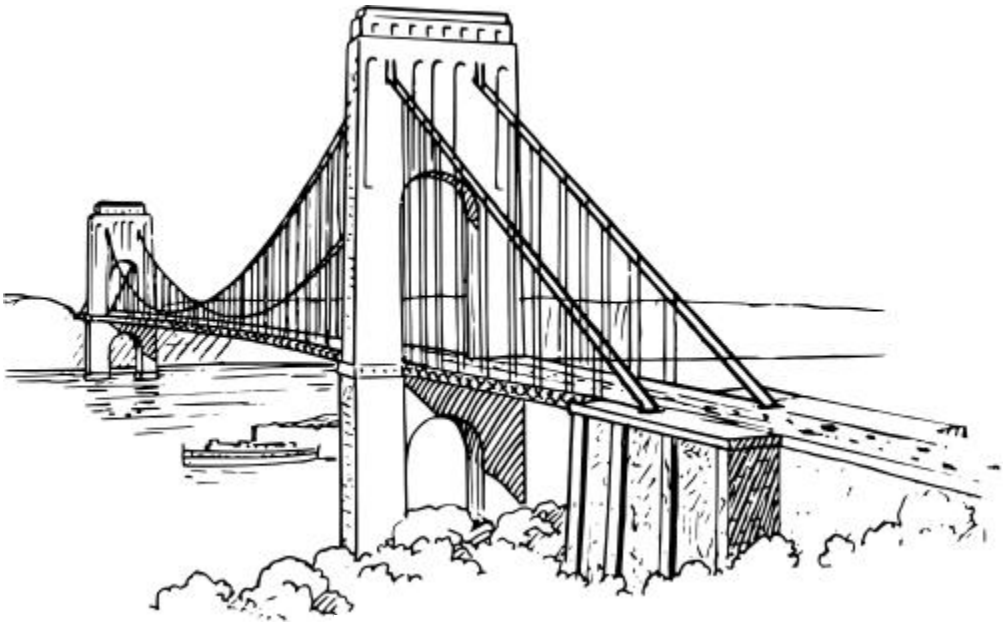
While he was born in Scotland, Sir James Brunlees (1816-1892) was a well-known resident of Wimbledon, located in the Borough of Merton. Throughout his career as a civil engineer, Brunlees built several railway bridges in England, Scotland, New Zealand, and even a bridge in Brazil. His most important piece of work was the railway across the Morecambe Bay. This bridge was built to provide an essential link between the railways in Northern England to the railways in Southern England. While the total railway was only 19 miles, 10 of those miles were across embankments and tidal waters consisting of sand from 30 to 70 feet deep; this deep sand made the project very difficult. Despite this challenge, five years after Brunlees took over the role of construction engineer, he completed the bridge and the railway opened the line. His work on this bridge earned him praise from esteemed engineers and many others used his techniques to build bridges, viaducts, and piers (Grace's Guide, 2015).

What Will Participants Do During This Program?



(en.wikipedia.org, Benwildeboer)

In this program, students will learn about the engineering design process and use this knowledge to design, construct, and test a balsa wood bridge. Prior to the construction, the program proctor will provide a presentation outlining the physics behind truss bridges and the design process the students will use to create their own. Using the designs of the railway bridges built by James Brunlees as a reference, students will design each portion of the balsa wood bridge to scale on engineering paper. Using their bridge designs as a template, students will use balsa wood and hot glue to construct each individual section of their bridge. Once students complete each section, they will carefully glue their bridge together and test if their bridge is able to hold a minimum weight without breaking. During this process students will observe and record the locations where stress or damage occurs. if the participant's holds the minimum weight, he or she can decide whether to continue testing and see the maximum weight their bridge can hold or they may take it home as a memento. Due to the complexity and length of the program, proctors should conduct this program over two or three sessions of about an hour.



(www.clipartpanda.com)

What Skill Will Participants Learn From This Program?

This bridge design program will teach participants about the engineering design process. Students who participate in the program will learn the basics about the methods engineers use to design, build, and test a model. After the first portion of the program, students will understand the basics of how engineers plan and draft their projects before the physical construction; they will be able to draw out a complete to-scale design. In the second portion of the program, students will learn how to construct individual sections and then configure a structure based on design documents. Finally, students will also learn the correct approach about how to test a prototype model; they will learn how to observe and record the weight and location of structural damage on their bridge.

What is the Importance of These Skills?

Possessing a firm understanding of the engineering design process is an essential component of engineering. While secondary school students may learn important science and maths concepts related to engineering, few learn about the process behind the design and development of a product. Learning this skill in secondary school will benefit students looking to pursue an engineering degree at a university, as they will already understand good engineering practices.

In addition, learning the correct methods about how to design and build a product is not only useful to students looking to pursue engineering. Students can apply these skills to any project; understanding this process may help students build furniture, make repairs around the house, or assist with a hobby.

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Outline and Suggested Timeline

1. Introduce the history and describe the activity to the participants. (10 min)
2. Demonstrate that balsa wood is very easy to break. (1 min)
3. Provide the participants with engineering paper and have them design the top, bottom, and sides of their bridges on the paper. (20-25 min)
4. Cut balsa wood and place it over their design, pinning the wood in place using pins (without piercing the wood). (10 min)
5. Glue the wood together and let the glue dry completely. (10 min)
6. Remove the pins and glue the pieces of the bridge together one-by-one, letting the glue dry completely each time. (20 min)
7. Place a weight on top of each bridge to see if it can support the minimum weight, have participants observe and record any damage. (10 min)
8. Explain to participants that even though the wood is easy to break that their designs made the bridges strong. (10 min)
9. Allow participants to take home their bridges. (1-2 min)

Note: This activity will take place over two sessions of approximately 60 minutes each. This timeline can be extended to take place over three sessions to give participants more time to complete their bridges. Participants may be at slightly different points by the conclusion of the first session but will most likely be at stage 5 or 6 of the activity.

Materials

- Balsa wood
- Engineering paper
- Hot glue
- Pins
- Small saw or knife to cut wood

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Brief Overview of the Science in this Program

When a force is applied to directly beam it must support the entirety of that weight without breaking. If beams are configured in a truss, or triangle, the weight is distributed and each bar will support less weight. Civil Engineers use trusses to minimize the weight on each steel beam to prevent them from breaking.

Suggested Participants and Groups

Due to the complexity of this program participants should be at least eleven years old. Participants should be able to complete tasks without constant supervision. This activity is best completed individually but in larger groups participants can work in groups of two.

Possible Issues

If a student's bridge does not meet the minimum weight and breaks, or if a student is concerned about their bridge breaking, we suggest that the program proctor allow these students to stay after the activity and use hot glue to repair any damage to their bridge.

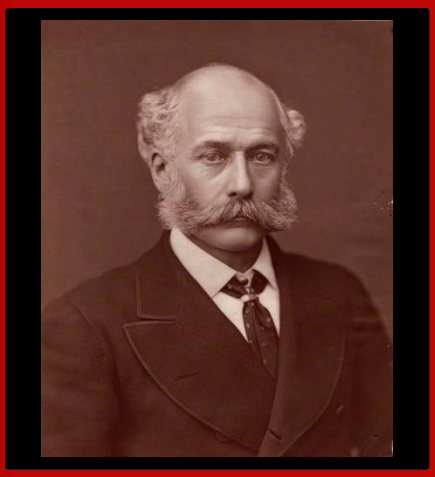
Section 4

The following pages contain the program description and outline for:

Fluid Flow and the Basics of Water Filtration

Fluid flow and the Basics of Water Filtration

What is the Local History Behind this Program?



(en.wikipedia.org)

During the mid-19th century poor sewer systems and water treatment caused recurring deadly outbreaks of cholera. In 1854-1855 alone this disease killed over 10,000 Londoners. Alongside the constant cholera outbreaks, the hot summer of 1858 combined with poor water treatment caused a stench permeating from the River Thames so great, that this smell became known as the "Great Stink of London". At was at this time when the chief engineer of London's metropolitan board of works and Merton resident, Joseph Bazalgette, was tasked by the city to redesign the antiquated sewer systems. His new sewer system intercepted the dirty water from old sewers and brought it down new low-level pipelines to updated treatment works. Alongside designing new pipelines, his plan involved major pumping stations and embankments on both sides of the River Thames. These pumping stations and embankments protected the sewers and underground railway while also reclaiming over 52 acres from the River Thames to use as roads and gardens. While designing the sewer, Bazalgette doubled all of this calculations for the diameters of the sewage pipelines to prepare for the 'unforeseen'. This foresight is a major reason why his sewage system is still in use today. By 1875, when Bazalgette completed the final pumping station, the new sewers had eliminated cholera outbreaks throughout the city. This sewer system designed by Joseph Bazalgette effectively saved tens of thousands of Londoners lives (BBC History. 2014).

What Will Participants Do During This Program?

During this program participants will learn about the Merton resident Joseph Bazalgette, the importance of the London sewer system which he designed, and the fundamental fluid dynamics concepts he employed in his design. Before engaging in the activities, the program proctor will introduce Joseph Bazalgette, note the deplorable conditions of the water in London during the mid-1800s, and mention how Bazalgette's new system cleaned the water in the city, ending the cholera epidemics and saving tens of thousands of lives. After the history lesson, participants will take part in two activities. The first activity is a hands-on demonstration of water filtration and fluid dynamics. With the help of volunteers participants will construct two separate 'sewage pipes' out of plastic tubing. One 'sewer' system will contain tubing with a small diameter and the second will contain tubing with a much larger diameter. In addition to the tubing, each system will incorporate two types of filters. The first filter will sift out large objects, like dirt and mud, from water. A simple coffee filter should work for large particle filtration. The second filter is designed to filter smaller particles, like food coloring, from water. Micro-particle filtration requires a different filter; participants or a program proctor can construct an acceptable filter by poking holes in the bottom of a soda bottle, adding layers of cotton balls, and adding sand on top. Alternatively, the program proctor may also use a filter from a sports water bottle, if available. Once participants complete the construction the program proctor should pour a mixture of water, dirt, and food coloring into each pipe system. Students should observe the differences in fluid velocity and filtration quality between each 'sewer' system. After the demonstration the proctor will discuss how filters block particles and formally explain the relationship between fluid velocity and area. This explanation will segway into a discussion about how Bazalgette doubled the diameters of all his pipes to prevent water from flowing too fast through them and is why his sewer system is still in use today. The second part of the program consists of another activity and a field trip. In addition to pipelines, Bazalgette also designed updated pump stations as part of his sewer system. Participants will use small motors, soda bottle caps, foam board, and straws to make a small water pump. Once participants build and test their small pumps they will travel to the Crossness Pump Station built by Bazalgette to see a piece of his work firsthand.

(en.wikipedia.org, Ethan Doyle White)

What Skills and Information Will Participants Learn From This Program?

During the first part of the activity students will not only learn the basics about fluid dynamics, they will learn how Joseph Bazalgette used these concepts to engineer a sewer system that saved tens of thousands of lives. From the water pump activity and subsequent field trip participants will learn how the material they learned during the program relates to real life applications.

What is the Importance of This Information?

This material is important because students may understand that engineering consists of using math and science to solve problems or innovate new technology, but few may understand the importance of this work and the effects engineering has on society. Understanding the widespread effect Joseph Bazalgette's work had on London will show students the importance of engineering and possibly inspire them to pursue a career in this field in hopes to one day to help the city like Bazalgette.

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Outline and Suggested Timeline

12. Introduce the history of the Joseph Bazalgette and discuss the importance of the London sewer system design. (15 min)
13. Construct fine particle filter by cutting the bottom off of a soda bottle, adding cotton balls, and then a lot of sand on top. (15 min)
14. Split participants in two groups, each with an adult supervisor, and have students construct the two pipelines using tubes and filters. The large particle filter should be about 12 inches away from the small particle filter to allow students to see the changes in water quality. (30 min)
15. Mix dirt and green food coloring into a large bucket of water. Using a funnel pour the liquid into the tubes. Repeat for the second tube system. (10 min)
16. Discuss observations with the participants. (5 min)
17. Relate participant observations back to Bazalgette and discuss the relationship between pipe area and fluid velocity. (10 min)
18. Split students into groups of two and have them construct a hand-made water pump using a small motor, two soda bottle caps, small piece of foam board, and a straw. (30 min)
19. Test water pumps using cups or pots of water. (5 min)
20. Go to the Crossness pump station to observe Bazalgette's water pumps and the station's decorative ironworks. (1.5 – 2 hr)

Materials

- Two diameters of clear plastic tubing.
- Several soda bottles
- Several small motors
- Buckets of water
- Food coloring
- Straws
- Sand, dirt
- Cotton balls, Coffee filters
- Hot glue
- 9 volt batteries

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Brief Overview of the Science in this Program

The mass flowrate of water through a pipe is directly proportional to the velocity multiplied by the area and the density. In a system where the mass flowrate of water does not change, a smaller area means a faster flow velocity. For filters to effectively clean water, it must flow slowly through the filtration material. That is why having a larger pipe is more effective in a sewage filtration system.

The spinning flap inside the water pump pulls water from the reservoir by creating a low pressure area inside the pump and then forces the water out the other end. Once the pump pushes out the water, the process is repeated.

Recommended Participants

We recommend that students aged 11 to 15 participate in this program. Even though the construction in these activities is slightly difficult, younger students can perform these activities with assistance from older students or program assistants.

Possible Issues

Due to the complexity of making homemade water pumps and multiple construction methods available that make use of the listed materials, we suggest Commonside research and test various designs to determine which one is the quickest and easiest to make.

We also suggest that program proctors do extensive testing to determine the best method to configure the piping systems, as this may take a long time if done incorrectly.

Section 5

The following pages contain the program description and outline for:

Textile Printing in the Old Merton Abbey Mills

Textile Printing in the Old Merton Abbey Mills

What is the Local History Behind this Program?

(merton.gov.uk)

During the British industrial era in the 19th century, the mills in the east Merton area were known for their textile printing factories. In 1881 Merton Abbey Mills was bought by famous textile designer William Morris and converted from a silk factory into a textile printing mill. Textile designing in this era was considered artisan work; designers required several years of training and apprenticeships before they were considered proficient in this craft. Textile print designers would hand carve a design into a printing block (similar to a stamp), carefully add individual colors of dye, and essentially stamp the design into textile (M. Taylor, personal communication, 6 April 2016).

What Will Participants Do During This Program?

(merton.gov.uk)

In this program participants will learn about the textile printing techniques used in the 18th and 19th century textile mills along the River Wandle, including the Merton Abbey Mills. With the assistance of volunteers from the Wandle Industrial Museum, participants will design their own printing blocks, mix their own dyes, and create a textile print on a piece of fabric. While the prints are drying, students will learn about the job of a textile designer and the years of training these designers required to join this occupation. As part of this explanation, the Wandle Industrial Museum will provide students with examples of advanced textile designs and explain how textile workers employed the same printing techniques as the participants to create these more complex designs.

(www.mertonabbeymills.org.uk)

What Skills and Information Will Participants Learn From This Program?

While this program is not specifically related to engineering, it teaches students about the creative design behind product production. This program aligns with the goal of science, technology, engineering, arts, and maths or STEAM, which is to incorporate design and creative thinking into programs relating to technology or engineering. In addition to learning skills related to creative design, participants will also learn to recognize how basic and introductory techniques incorporate into advanced or complex designs.

What is the Importance of This Information?

Boosting creativity through hands-on design will help students think of creative and innovative solutions when approaching a problem. Even though students may have a firm understanding of the science and construction methods required to solve a design problem, they may lack the creativity required to come up with an innovative solution. While not engineering design specific, creating a unique printing block will encourage students to think creatively about their designs.

By providing students with explanations about how the basic techniques they learned are applied in complex textile print designs; they will learn how to apply the skills they learned to different and more advanced applications. By explaining to students that what they learned is not an isolated skill, but rather part of a bigger application, they may apply similar forms of thinking in other subjects and become more receptive to understanding advanced topics.

Brief Program Outline

In the section below, we provide a brief overview of this program and a suggested timeline for the activities.

Outline and Suggested Timeline

21. **Presentation about the history of textile printing, led by the Wandle Industrial Museum volunteers. (10 min)**
22. **Participants create printing blocks. (20 mins)**
23. **Participants mix their preferred colors of dye. (10 mins)**
24. **Participants make their textile prints, led by the Wandle Industrial Museum volunteers. (20 mins)**
25. **Show and discuss advanced or complex textile printing designs. Discuss how the techniques participates learned are incorporated into these designs. (15 mins)**
26. **Students bring home their textile prints. (5 mins)**

Materials

- **Textile fabric**
- **Various colors of dye**
- **Printing blocks from museum volunteers**
- **foam so participants can make their own designs**
- **Examples of advanced or complex textile prints**

Recommended Participants

Due to the simplicity of this program, we recommend this program to students aged 8 to 12 years old.

Possible Issues

Since the Wandle Industrial Museum has limited hours of operation, date and time coordination may be difficult and must be completed far in advance.

1

Appendix J

Raw data from our survey given to students at St. Mark's Academy in Mitcham appears below

Q1 to Q7

9	Female	Unsure	Yes	No	Somewhat Agree	Strongly Disagree	Strongly Agree	Strongly Agree
9	Female	Unsure	Yes	Yes	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree
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11	Prefer not to say	Yes	Yes	Yes	Somewhat Agree	Strongly Disagree	Strongly Agree	Strongly Agree
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14	Female	No	No	No	Somewhat Agree	Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree
14	Female	No	No	No	Somewhat Agree	Somewhat Agree	Somewhat Disagree	Somewhat Disagree
14	Female	Unsure	No	No	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree
14	Male	Yes	No	No	Strongly Agree	Somewhat Disagree	Somewhat Agree	Neither Agree nor Disagree
14	Male	Yes	No	Yes	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Disagree
14	Male	Unsure	No	Yes	Somewhat Agree	Somewhat Disagree	Strongly Agree	Somewhat Agree
14	Female	No	Yes	No	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree
14	Male	No	No	No	Somewhat Disagree	Strongly Agree	Strongly Disagree	Strongly Disagree
14	Female	No	Unsure	Unsure	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Neither Agree nor Disagree
15	Male	No	Yes	Yes	Strongly Agree	Somewhat Disagree	Somewhat Agree	Somewhat Agree
15	Male	Yes	No	Yes	Strongly Agree	Strongly Disagree	Strongly Agree	Somewhat Agree
15	Female	No	No	Yes	Neither Agree nor Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Disagree
15	Male	Unsure	Yes	Yes	Somewhat Agree	Strongly Disagree	Somewhat Agree	Somewhat Agree
15	Female	No	No	No	Somewhat Agree			Strongly Agree
15	Female	No	No	No	Somewhat Disagree	Somewhat Disagree	Somewhat Agree	Neither Agree nor Disagree

15	Female	Yes	No	No	Strongly Agree	Somewhat Disagree	Strongly Agree	Strongly Agree
15	Female	Unsure	Unsure	Unsure	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
15	Male	No	No	Yes	Strongly Agree	Strongly Disagree	Neither Agree nor Disagree	Strongly Agree
15	Female	No	No	No	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree
15	Male	Unsure	Yes	Yes	Somewhat Agree	Strongly Disagree	Somewhat Agree	Strongly Agree
15	Male	No	Yes	Unsure	Strongly Agree	Somewhat Disagree	Somewhat Agree	Strongly Agree
15	Female	No	Yes	Yes	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
15	Female	No	No	No	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree
15	Male	Yes	No	No	Strongly Agree	Somewhat Disagree	Strongly Agree	Somewhat Agree
15	Female	No	Yes	No	Somewhat Agree	Strongly Disagree	Neither Agree nor Disagree	Somewhat Agree
15	Female	Yes	No	Yes	Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree
15	Female	No	No	No	Strongly Agree	Neither Agree nor Disagree	Strongly Agree	Strongly Disagree
15	Female	No	Unsure	No	Somewhat Agree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
15	Female	No	No	No	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Disagree
15	Male	Unsure	No	No	Somewhat Agree	Somewhat Disagree	Somewhat Disagree	Somewhat Disagree
15	Male	Yes	Unsure	No	Somewhat Agree	Strongly Disagree	Strongly Agree	Somewhat Agree
15	Male	Yes	No	No	Somewhat Agree	Strongly Disagree	Strongly Agree	Strongly Agree
16	Male	No	No	No	Strongly Agree	Strongly Disagree	Strongly Agree	Somewhat Disagree
16	Male	No	No	No	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree
17	Male	Unsure	Yes	Yes	Somewhat Agree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree
17	Male	Yes	No	Yes	Strongly Agree	Strongly Disagree	Strongly Agree	Strongly Agree
17	Male	Unsure	Unsure	No	Somewhat Agree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
18	Male	Unsure	No	No	Neither Agree nor Disagree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
18	Female	No	No	Yes	Somewhat Agree	Strongly Disagree	Somewhat Agree	Somewhat Agree
18	Female	No	No	Unsure	Somewhat Agree	Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree
18	Male	No	Yes	No	Somewhat Agree	Somewhat Disagree	Somewhat Agree	Strongly Disagree
18	Female	No	Yes	No	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree
18	Male	No	Yes	Yes	Strongly Agree	Strongly Agree	Strongly Agree	Somewhat Agree
19	Male	No	Yes	Yes	Somewhat Agree	Strongly Disagree	Somewhat Agree	Strongly Agree
19	Female	No	No	Yes	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree

19	Male	No	No	No	Somewhat Agree	Somewhat Disagree	Somewhat Disagree	Somewhat Disagree
	Male	No	No	No	Strongly Disagree	Strongly Agree	Strongly Disagree	Strongly Disagree

Q8 to Q12

Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Disagree	Strongly Agree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Disagree
Strongly Disagree				Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Somewhat Disagree	Strongly Disagree	Strongly Agree		Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Somewhat Disagree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Neither Agree nor Disagree	Neither Agree nor Disagree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Agree	Strongly Agree	Neither Agree nor Disagree	Strongly Agree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Disagree	Somewhat Disagree	Strongly Agree	Somewhat Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Somewhat Agree
Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Agree	Somewhat Disagree	Strongly Disagree
Strongly Agree	Neither Agree nor Disagree	Strongly Agree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Disagree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Agree
Strongly Disagree	Strongly Disagree	Somewhat Agree	Somewhat Agree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Somewhat Agree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Disagree	Neither Agree nor Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Somewhat Disagree	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Somewhat Disagree	Strongly Agree
Somewhat Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Agree	Strongly Agree	Somewhat Agree	Somewhat Agree	Neither Agree nor Disagree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree		Strongly Agree	Strongly Agree	Strongly Agree
Somewhat	Somewhat	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree

Disagree	Disagree							
Somewhat Disagree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Agree
Somewhat Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Somewhat Disagree	Somewhat Agree
Strongly Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Disagree	Strongly Agree	Strongly Agree	Somewhat Disagree	Somewhat Agree
Somewhat Disagree	Strongly Agree	Somewhat Agree	Strongly Agree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Strongly Agree	Neither Agree nor Disagree
Strongly Disagree	Somewhat Disagree			Strongly Disagree	Somewhat Disagree	Strongly Disagree	Somewhat Agree	Strongly Agree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
Strongly Agree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Somewhat Disagree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Somewhat Agree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Disagree	Strongly Agree	Somewhat Disagree	Neither Agree nor Disagree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Disagree	Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree	Strongly Agree
Somewhat Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree
Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree
Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Disagree	Somewhat Disagree	Somewhat Agree	Somewhat Disagree	Somewhat Agree
Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree
Strongly Agree	Somewhat Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Agree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree
Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat	Somewhat Agree	Strongly Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree

			Disagree					
Strongly Disagree	Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Agree
Strongly Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree	Strongly Disagree	Somewhat Disagree	Strongly Agree	Somewhat Agree	Somewhat Agree
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Strongly Disagree	Somewhat Disagree	Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree			
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Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Strongly Disagree	Somewhat Disagree
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Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Disagree	Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Somewhat Agree
Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
Somewhat Agree	Somewhat Disagree	Neither Agree nor Disagree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Agree
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Somewhat Disagree	Neither Agree nor Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Somewhat Agree

Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Somewhat Agree	Strongly Disagree
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Strongly Agree	Strongly Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree			
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Strongly Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree
Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Disagree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Neither Agree nor Disagree	Somewhat Disagree	Strongly Agree	Somewhat Disagree	Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Agree
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Strongly Agree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Neither Agree nor Disagree
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Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Strongly Disagree	Somewhat Agree	Strongly Agree
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Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Disagree	Somewhat Agree	Strongly Disagree	Strongly Agree	Strongly Agree	Somewhat Agree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
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Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree
Strongly Agree	Strongly Disagree	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Somewhat Agree	Strongly Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree
Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Neither Agree nor Disagree	Neither Agree nor Disagree
Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Somewhat Agree
Strongly Agree	Somewhat	Somewhat Agree	Neither Agree nor	Somewhat Agree	Somewhat	Somewhat Agree	Somewhat Agree	Neither Agree nor

	Disagree		Disagree		Disagree			Disagree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Somewhat Disagree	Somewhat Disagree	Strongly Agree	Somewhat Agree	Somewhat Agree
Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Disagree	Neither Agree nor Disagree
Strongly Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Disagree	Somewhat Disagree	Somewhat Disagree	Somewhat Agree	Somewhat Agree	Strongly Agree
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Somewhat Agree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree
Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Disagree	Somewhat Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree
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Strongly Disagree	Strongly Agree	Strongly Agree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree
Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Disagree	Strongly Disagree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree
Somewhat Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Neither Agree nor Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Agree
Somewhat Agree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree
Somewhat Disagree	Strongly Disagree	Neither Agree nor Disagree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Strongly Agree
Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Strongly Agree	Strongly Agree
Somewhat Agree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree
Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Agree
Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Neither Agree nor Disagree
Somewhat Disagree	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree	Somewhat Disagree	Strongly Agree

Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Neither Agree nor Disagree	Strongly Disagree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Somewhat Disagree	Somewhat Disagree	Somewhat Agree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree
Neither Agree nor Disagree	Somewhat Disagree	Strongly Agree	Somewhat Disagree	Somewhat Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Somewhat Agree	Somewhat Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Somewhat Agree	Strongly Agree
Strongly Agree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Agree	Somewhat Agree	Strongly Agree	Strongly Agree	Somewhat Agree
Somewhat Agree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Agree
Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Somewhat Agree
Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Disagree	Somewhat Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Somewhat Disagree	Somewhat Disagree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Agree	Somewhat Agree	Somewhat Agree
Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree	Strongly Disagree
Strongly Disagree	Somewhat Agree	Strongly Disagree	Strongly Disagree	Strongly Agree	Strongly Disagree	Strongly Agree	Strongly Disagree	Strongly Agree
Strongly Disagree	Strongly Disagree	Neither Agree nor Disagree	Somewhat Disagree	Somewhat Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Strongly Disagree	Somewhat Agree	Strongly Agree	Strongly Agree	Neither Agree nor Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Strongly Agree
Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Disagree	Strongly Agree	Somewhat Disagree	Strongly Agree	Strongly Agree	Somewhat Agree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree	Strongly Agree
Strongly Disagree	Neither Agree nor Disagree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Somewhat Disagree	Somewhat Agree	Somewhat Agree	Somewhat Agree
Somewhat Agree	Strongly Agree	Somewhat Agree	Somewhat Disagree	Somewhat Agree	Strongly Agree	Strongly Agree	Strongly Agree	Somewhat Disagree
Strongly Disagree	Somewhat Disagree	Strongly Agree	Somewhat Disagree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Disagree	Neither Agree nor Disagree
Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree
Strongly Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Somewhat Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree

Strongly Disagree	Strongly Disagree	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Neither Agree nor Disagree	Strongly Agree	Strongly Agree	Strongly Agree
Somewhat Agree	Strongly Agree	Strongly Agree	Somewhat Agree	Somewhat Disagree	Strongly Agree	Strongly Agree	Somewhat Agree	Somewhat Agree
Strongly Agree	Strongly Agree	Somewhat Agree	Somewhat Agree	Neither Agree nor Disagree	Strongly Disagree	Strongly Agree	Strongly Disagree	Somewhat Agree

Q13

Rejected	Rejected	Ideal	Ideal	Expected	Ideal	Tolerable	Expected	Expected	Ideal	Expected	Ideal	Tolerable	Ideal	artis
Expected	Expected	Rejected	Ideal	Ideal	Ideal	Expected	Rejected	Ideal	Rejected	Rejected	Tolerable	Tolerable	Tolerable	
Expected	Tolerable	Ideal	Expected	Rejected	Ideal	Tolerable	Ideal	Rejected	Ideal	Ideal	Tolerable	Expected	Ideal	
Ideal	Ideal	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Ideal	Rejected	Rejected	Ideal	Rejected		
Tolerable	Tolerable	Tolerable	Ideal	Ideal	Ideal	Tolerable	Ideal	Rejected	Rejected		Tolerable	Rejected		
Rejected	Rejected	Ideal	Ideal	Rejected	Rejected	Rejected	Rejected	Ideal	Rejected	Ideal	Rejected	Rejected		
Tolerable	Rejected		Expected					Rejected						
Ideal	Rejected	Ideal	Ideal	Expected	Ideal	Expected	Tolerable	Rejected	Rejected	Ideal	Ideal	Ideal	Ideal	car sales
Ideal	Rejected	Expected	Ideal	Expected	Tolerable	Expected	Rejected	Ideal	Rejected	Expected	Ideal	Expected	Ideal	maths teacher
Ideal	Tolerable	Expected	Expected	Rejected	Tolerable	Tolerable	Ideal	Tolerable	Rejected	Ideal	Expected	Expected	Ideal	football
Expected	Rejected	Ideal	Rejected	Tolerable	Tolerable	Tolerable	Expected	Rejected	Expected	Ideal	Expected	Tolerable	Ideal	cooking (chef)
Tolerable	Rejected	Expected	Expected	Rejected	Expected		Tolerable	Rejected	Tolerable	Tolerable	Expected	Rejected	Ideal	lawyer
Rejected	Tolerable	Rejected	Rejected	Tolerable	Rejected	Rejected	Rejected	Rejected	Tolerable	Tolerable	Expected	Rejected	Ideal	to teach equestiran sport
Tolerable	Rejected	Tolerable	Tolerable	Tolerable	Expected	Rejected	Rejected	Expected	Expected	Expected	Rejected	Rejected	Ideal	car sales
Rejected	Rejected	Tolerable	Rejected	Ideal	Tolerable	Tolerable	Rejected	Ideal	Rejected	Ideal	Ideal	Expected		
Expected	Rejected	Ideal	Expected	Ideal	Ideal	Expected	Expected	Rejected	Expected	Tolerable	Expected	Expected		
Tolerable	Rejected	Ideal	Ideal	Ideal	Ideal	Tolerable	Ideal	Tolerable	Ideal	Expected	Tolerable	Tolerable		
Rejected	Rejected	Tolerable	Expected	Ideal	Tolerable	Rejected	Expected	Rejected	Rejected	Rejected	Tolerable	Rejected		
Tolerable	Rejected	Tolerable	Tolerable	Expected	Ideal			Rejected	Ideal	Rejected	Ideal			youtuber
														tatoo artis
Tolerable	Rejected	Rejected	Rejected	Expected	Expected	Tolerable	Tolerable	Rejected	Tolerable	Tolerable	Tolerable	Ideal	Ideal	Comic Creater
Ideal	Tolerable	Tolerable	Tolerable	Expected	Tolerable	Tolerable	Tolerable	Expected	Expected	Ideal	Tolerable	Expected	Ideal	astronaut

Ideal	Tolerable	Ideal	Expected	Ideal	Ideal	Ideal	Expected	Rejected	Tolerable	Ideal	Ideal	Tolerable	Ideal	space = astnort
Rejected	Rejected	Ideal	Tolerable	Rejected	Ideal	Rejected	Ideal	Tolerable	Rejected	Ideal	Tolerable	Tolerable	Ideal	lawyer
Rejected	Rejected	Rejected	Tolerable	Rejected	Rejected	Rejected	Rejected	Rejected	Expected	Rejected	Rejected	Tolerable	Ideal	singer/actress
Rejected	Rejected	Expected	Tolerable	Tolerable	Expected	Rejected	Expected	Rejected	Tolerable	Expected	Tolerable	Rejected	Ideal	Performer e.g. actress, singer
Rejected	Rejected	Rejected	Tolerable	Rejected	Rejected	Rejected	Tolerable	Rejected	Rejected	Expected	Tolerable	Rejected	Ideal	Dentistry
	Rejected												Ideal	something creative e.g. creating logos
Rejected	Rejected	Ideal	Tolerable	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Expected	Rejected	Rejected	Rejected	
Ideal	Ideal	Ideal	Rejected	Ideal	Expected	Rejected	Expected	Ideal	Ideal	Ideal	Ideal	Ideal		
Rejected	Ideal	Ideal	Ideal	Expected	Tolerable	Tolerable	Ideal	Rejected	Tolerable	Tolerable	Ideal	Ideal		
Rejected	Rejected	Ideal	Expected	Tolerable	Tolerable		Expected	Rejected	Tolerable	Rejected	Rejected	Ideal		actress/singer
Expected	Rejected	Expected	Expected	Expected		Expected	Expected	Rejected	Tolerable	Ideal	Expected	Expected		
											Tolerable	Expected		
											Ideal	Tolerable		
Expected	Rejected	Rejected	Rejected	Expected	Expected	Rejected	Ideal	Rejected	Ideal	Tolerable	Expected	Tolerable		
Rejected	Tolerable	Ideal	Ideal	Tolerable	Ideal	Rejected	Ideal	Expected	Rejected	Rejected	Ideal	Rejected		
Rejected	Rejected	Tolerable	Tolerable	Tolerable	Tolerable	Rejected	Tolerable	Rejected	Expected	Expected	Expected	Rejected		
Tolerable	Rejected	Ideal	Expected	Tolerable	Rejected	Rejected	Rejected	Rejected	Tolerable	Rejected	Expected	Rejected		
	Rejected	Ideal	Tolerable	Expected	Expected	Rejected	Tolerable	Rejected	Tolerable		Expected	Rejected		
Rejected	Rejected	Ideal	Ideal	Expected	Tolerable	Tolerable	Tolerable	Rejected	Rejected	Tolerable	Tolerable	Rejected		
Tolerable	Rejected	Ideal	Rejected	Tolerable	Tolerable	Rejected	Expected	Rejected	Expected	Ideal	Rejected	Rejected		
Rejected					Tolerable						Ideal			
		Ideal		Rejected					Expected					
Tolerable	Rejected	Ideal	Ideal	Ideal	Rejected	Tolerable	Expected	Rejected	Tolerable	Tolerable	Ideal	Tolerable	Ideal	midwife

Rejected	Rejected	Rejected	Rejected	Tolerable	Rejected	Rejected	Expected	Rejected	Expected	Tolerable	Tolerable	Tolerable	Ideal	hair dresser
Tolerable	Rejected	Ideal	Expected	Expected	Tolerable	Expected	Tolerable	Rejected	Expected	Tolerable	Rejected	Tolerable	Ideal	Pharmistcist
Ideal	Rejected	Expected	Rejected	Tolerable	Ideal	Tolerable	Tolerable	Tolerable	Rejected	Expected	Expected	Rejected	Ideal	desinger enginer
Rejected	Rejected	Rejected	Rejected	Rejected	Expected	Rejected	Ideal	Rejected	Tolerable	Rejected	Tolerable	Rejected	Ideal	celebrity (actress)
Tolerable	Expected	Expected	Rejected	Tolerable	Tolerable	Tolerable	Tolerable	Rejected	Expected	Expected	Rejected	Rejected	Ideal	nything to do with cooking or art
Rejected	Rejected	Expected	Expected	Expected	Ideal	Expected	Expected	Expected	Expected	Tolerable	Rejected	Rejected	Ideal	lawyer
Rejected	Rejected	Rejected	Rejected	Expected	Expected	Tolerable	Tolerable	Tolerable	Tolerable	Rejected	Tolerable	Rejected	Expected	art, design, lawyer
Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Rejected	Tolerable	Tolerable	
Ideal	Ideal	Ideal	Tolerable	Tolerable	Expected	Expected	Expected	Ideal	Tolerable	Expected	Ideal	Ideal	Rejected	
Ideal	Rejected	Tolerable	Tolerable	Tolerable	Expected	Ideal	Ideal	Tolerable	Tolerable	Ideal	Tolerable	Expected	Rejected	
Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Rejected	Expected	Tolerable	Rejected	Expected	Rejected	Rejected	
Ideal										Tolerable			Rejected	programming
Ideal	Rejected	Rejected	Rejected	Rejected	Rejected	Tolerable	Expected	Rejected	Expected	Expected	Ideal	Ideal		
Expected	Tolerable	Ideal	Expected	Tolerable	Tolerable	Tolerable	Tolerable	Ideal	Tolerable	Ideal	Expected	Ideal		
Rejected	Rejected	Rejected	Expected	Expected	Ideal	Expected	Ideal	Rejected	Ideal	Expected	Expected	Expected		
Expected	Rejected	Ideal	Ideal		Ideal		Expected		Tolerable	Ideal	Rejected	Tolerable		
Expected	Rejected	Ideal	Expected	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Expected	Rejected	Ideal	Rejected		
Expected		Tolerable			Ideal		Tolerable	Rejected	Tolerable		Ideal	Rejected		
Rejected		Ideal	Ideal	Rejected	Tolerable	Rejected	Rejected	Rejected	Rejected	Ideal	Rejected	Rejected		
Expected	Rejected	Rejected	Rejected	Tolerable	Rejected	Rejected	Rejected	Rejected	Rejected	Tolerable	Rejected	Rejected		
Ideal	Rejected							Expected	Ideal		Ideal			
Tolerable								Rejected	Expected		Ideal			
		Expected								Tolerable	Rejected			
Ideal	Rejected	Expected	Rejected	Expected	Ideal	Expected	Expected	Expected	Ideal	Expected	Tolerable	Ideal	Ideal	electrician
Rejected	Rejected	Ideal	Expected	Tolerable	Expected	Tolerable	Expected	Expected	Rejected	Rejected	Ideal	Tolerable	Ideal	drama
Rejected	Tolerable	Tolerable	Tolerable	Rejected	Rejected	Rejected	Tolerable	Rejected	Tolerable	Rejected	Tolerable	Tolerable	Ideal	child minder
Rejected	Rejected	Rejected	Rejected	Tolerable	Ideal	Tolerable	Expected	Tolerable	Expected	Expected	Rejected	Tolerable	Ideal	accountant
Ideal	Expected	Ideal	Ideal	Expected	Expected	Expected	Ideal	Rejected	Expected	Rejected	Rejected	Tolerable	Ideal	police officer

Rejected	Rejected	Tolerable	Tolerable	Rejected	Expected	Tolerable	Expected	Rejected	Tolerable	Rejected	Tolerable	Rejected	Ideal	music produnction/singer/artist
Ideal	Tolerable	Expected	Rejected	Tolerable	Rejected	Rejected	Tolerable	Ideal	Tolerable	Expected	Rejected	Rejected	Ideal	self employed - winter
Tolerable	Rejected	Rejected	Rejected	Ideal	Expected	Tolerable	Expected	Rejected	Expected	Tolerable	Rejected	Rejected	Ideal	Architecture
Rejected	Rejected	Tolerable	Tolerable	Tolerable	Rejected	Rejected	Expected	Rejected	Rejected	Rejected	Rejected	Rejected	Ideal	art
								Tolerable			Expected		Ideal	forensic science
Tolerable	Rejected	Ideal	Expected	Tolerable	Ideal	Rejected	Tolerable	Tolerable	Tolerable	Ideal	Expected	Tolerable	Expected	Health and medical services
Rejected	Rejected	Tolerable	Rejected	Expected	Ideal	Rejected	Ideal	Tolerable	Expected	Rejected	Expected	Tolerable	Expected	owning my own young offenders help agency
Expected	Rejected	Ideal	Tolerable	Rejected	Ideal	Expected	Expected	Rejected	Ideal	Ideal	Tolerable	Tolerable	Rejected	Hair dresser
Rejected	Rejected	Ideal	Expected	Ideal	Expected	Tolerable	Expected	Expected	Tolerable	Ideal	Tolerable	Expected		
Rejected	Rejected	Expected	Expected	Tolerable	Ideal	Expected	Ideal	Tolerable	Expected	Expected	Ideal	Tolerable		English Teacher
Tolerable	Expected	Expected	Tolerable	Expected	Tolerable	Tolerable	Tolerable	Expected	Tolerable	Rejected	Expected	Tolerable		
Ideal	Rejected	Expected	Tolerable	Ideal	Expected	Expected	Tolerable	Rejected	Tolerable	Rejected	Tolerable	Tolerable		
Tolerable	Tolerable	Ideal	Rejected	Rejected	Expected	Tolerable	Tolerable	Rejected	Expected	Ideal	Rejected	Tolerable		
Rejected	Rejected	Expected	Expected	Tolerable	Tolerable	Rejected	Rejected	Rejected		Rejected	Rejected	Tolerable		
Ideal	Rejected	Rejected	Rejected	Rejected	Expected	Ideal	Rejected	Tolerable	Expected	Ideal	Rejected	Rejected		
		Expected	Tolerable		Expected						Ideal			
Expected	Tolerable	Expected	Rejected		Ideal		Rejected	Tolerable			Tolerable			
	Rejected			Ideal	Ideal				Expected					
														football
Tolerable	Tolerable	Rejected	Rejected	Rejected	Rejected	Tolerable	Tolerable	Rejected	Rejected	Tolerable	Rejected	Ideal	Ideal	Piloting
Ideal	Rejected	Rejected	Tolerable	Tolerable	Expected	Expected	Expected	Expected	Expected	Expected	Rejected	Expected	Ideal	mechanic
Rejected	Rejected	Rejected	Tolerable	Rejected	Ideal	Rejected	Tolerable	Rejected	Tolerable	Rejected	Ideal	Rejected	Ideal	sport athlete
Ideal	Rejected	Rejected	Tolerable	Tolerable	Expected	Expected	Expected	Rejected		Tolerable	Tolerable	Rejected	Ideal	gamer

Tolerable	Rejected	Ideal	Expected	Expected	Ideal	Expected	Ideal	Rejected	Tolerable	Ideal	Rejected	Rejected	Ideal	actress
Rejected	Rejected	Rejected	Rejected	Rejected	Tolerable	Rejected	Tolerable	Rejected	Tolerable	Rejected	Rejected	Rejected	Ideal	entrepreneurship or film studies
Expected	Rejected	Tolerable	Tolerable	Rejected	Expected	Expected	Rejected	Tolerable	Rejected	Expected	Tolerable	Tolerable	Expected	maybe doctor
Tolerable	Expected	Expected	Expected	Ideal	Expected	Ideal	Expected	Tolerable	Tolerable	Expected	Ideal	Expected	Tolerable	
Expected	Rejected	Ideal	Ideal	Expected	Tolerable	Tolerable	Rejected	Tolerable	Rejected	Ideal	Expected	Expected		
Tolerable	Rejected	Ideal	Expected	Ideal	Ideal	Expected	Expected	Rejected	Tolerable	Expected	Ideal	Tolerable		
Expected	Rejected	Tolerable	Tolerable	Rejected	Ideal	Expected	Expected	Tolerable	Expected	Expected	Expected	Tolerable		
Expected	Rejected	Ideal	Expected	Tolerable	Tolerable	Rejected	Tolerable	Tolerable	Rejected	Expected	Expected	Tolerable		
Tolerable	Rejected	Ideal	Expected	Ideal	Expected	Tolerable	Tolerable	Tolerable	Rejected	Expected	Tolerable	Tolerable		
Tolerable	Tolerable	Tolerable	Tolerable	Ideal	Ideal	Tolerable	Ideal	Expected	Ideal	Tolerable	Rejected	Tolerable		
Expected	Rejected	Tolerable	Tolerable	Tolerable	Rejected	Tolerable	Tolerable	Ideal	Tolerable	Tolerable	Expected	Rejected		
Tolerable	Rejected	Tolerable	Rejected	Tolerable	Tolerable	Rejected	Tolerable	Rejected	Rejected	Expected	Tolerable	Rejected		
Expected	Rejected	Ideal	Tolerable	Tolerable	Tolerable	Rejected	Expected	Rejected	Rejected	Ideal	Rejected	Rejected		
Expected	Tolerable	Ideal	Expected	Rejected	Tolerable	Expected	Rejected	Rejected	Ideal	Expected	Rejected	Rejected		
Tolerable	Rejected	Ideal	Ideal	Ideal	Tolerable	Tolerable	Tolerable	Tolerable	Tolerable	Expected	Rejected	Rejected		
Expected	Rejected	Rejected	Tolerable	Rejected	Rejected	Expected	Tolerable	Rejected	Expected	Rejected	Rejected	Rejected		
Ideal	Expected	Expected	Ideal	Tolerable	Expected	Tolerable	Rejected	Tolerable	Tolerable	Ideal	Ideal			
Ideal			Ideal			Rejected								
Ideal	Rejected	Rejected	Rejected	Expected	Tolerable	Ideal	Rejected	Ideal	Expected	Tolerable	Ideal	Expected		
						Rejected						Tolerable		
	Rejected						Expected	Rejected	Ideal	Tolerable	Expected	Ideal	Rejected	
Ideal	Rejected	Rejected	Rejected	Tolerable	Ideal	Tolerable	Expected	Expected	Expected	Expected	Ideal	Expected		
Expected	Rejected	Ideal												
Expected	Rejected	Expected	Expected	Rejected	Expected	Ideal	Ideal	Expected	Tolerable	Tolerable	Ideal	Expected		
Tolerable	Tolerable	Ideal	Expected	Expected	Ideal	Tolerable	Expected	Tolerable	Tolerable	Ideal	Rejected	Rejected		
Tolerable	Rejected	Ideal	Expected	Rejected	Expected	Tolerable	Tolerable	Rejected	Expected	Tolerable	Rejected	Rejected		
Expected	Rejected		Ideal	Ideal	Expected	Tolerable	Ideal		Expected	Tolerable		Rejected		
	Rejected				Ideal				Expected			Rejected		
				Tolerable				Tolerable						

		Expected								Tolerable	Ideal		Ideal	Geographer
Expected	Rejected	Ideal	Rejected	Rejected	Expected	Rejected	Rejected	Rejected	Tolerable	Ideal	Rejected	Rejected		