AC 2011-1629: ENGINEERING PERSPECTIVES OF GRADE 7 STUDENTS

Mary Elizabeth Spencer, Queen's University
David S Strong, Queen's University

Professor David S. Strong has held the NSERC Chair in Design Engineering since joining Queen's University in 2003. His previous experience includes 22 years in the private sector in research, development, and manufacturing with three companies spanning the metals, biomedical, and consumer products industries.

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Abstract

Many high school students are unable to consider engineering as an undergraduate program of study because they do not have the prerequisite courses required for university entrance. In order to provide the opportunity for capable students to pursue an engineering degree and subsequently enter the engineering profession, they must understand what engineering is prior to entering high school to enable them to select appropriate courses.

The focus of this study is to understand how students in 7th grade perceive the profession of engineering in two regions across Canada. The literature suggests that action is underway in some areas of the United States in order to create awareness and encourage students to pursue an engineering program. These initiatives range from integrating engineering concepts into the K-12 curriculum to providing outreach and design challenge opportunities outside of school. Such initiatives are present in very isolated cases within Canada, however, their reach and impact is limited.

In order to better understand the perspective of pre-high school students in Canada, sample groups will be provided with a survey incorporating a variety of questions pertaining to what they understand about engineering as a profession. All questions have been structured as open ended in order to promote individualized answers from the students. Survey questions will be analyzed with NVIVO software to determine if there are common themes in the understanding and perception of engineering from the students' perspective. Observations and emerging trends of this work in progress will be presented in this paper.

Introduction

Historically, engineering occupations have grown faster than other professions (1). But while engineering job opportunities have increased, the number of degrees earned in these fields has not matched the demand. Twenty-six percent of employees in engineering are over the age of 50; in the coming decade society will be losing a quarter of its skilled workers (1).

For Canada to increase its economic development through innovation, a change must occur that draws more students into engineering. As stated by Mr. Boivin, chief operating officer of the Association of Canadian Engineering Companies, "We have growth in numbers, but the issue is that we have a shortage of engineers, particularly at the project management level. We need to address this issue – we need to convince young people, both men and women, to go into the sciences, into mathematics, and then into private-sector consulting work (2)." The issue of students entering engineering programs has been emphasized as a challenge facing engineering educators (3). A variety of initiatives have been developed, from multi-day engineering summer camps to one day activities introducing students to engineering.

In order to further develop these efforts in a manner that achieves the greatest impact, it is important to understand the current knowledge and awareness of the engineering profession at the pre-high school level. The purpose of this first phase of a multi-phase study is to describe, from the perspective of grade 7 students, what engineering means. They will be asked how they define and interpret, or recognize and value, the word "engineering" through the use of written

surveys and interviews. Based upon the results of this investigation, it is anticipated that optimized assistive programs can be developed for teachers to provide broader awareness of, and encouragement for, the engineering profession as a career choice. It is also expected that this research will assist in making improvements to current outreach and engineering awareness programs.

Methodology

In order to properly answer the research question of "what do participants think of engineering?" qualitative research is necessary. Qualitative research allows the researcher to understand the perspectives of the participants in depth and detail (4) . It is important to understand what the participants think and understand about the engineering profession and their logic and reasoning behind it. This is only achievable through qualitative research.

Method

This study has participants from both Ontario and Alberta. The reason for the location range in participants is to better account for the provincially managed educational systems. Open ended surveys and semi-structured interviews are the means of collecting data for this study. The participants, surveys, and results are described in detail below.

Participants

The participants in this research study are grade 7 students in Ontario and Alberta. The reason for selecting this group is that students in grade 7 are nearing a point where they will have to form their own thoughts and opinions about schooling options, possibly based on their knowledge (or lack thereof) regarding career choices. This is where it is believed that outreach may have the greatest impact in order to help students make informed choices. Once students enter high school and select courses, they may very quickly find themselves limited in post-secondary study options due to a lack of awareness of courses necessary for certain programs such as engineering. The long term intention of this research is to better inform students of the depth, breadth, and opportunities within the engineering profession prior to entering high school.

Survey

A written survey was used as the initial data collection method. The survey was structured as all open ended questions in order to elicit a variety of responses from the participants. It was developed by the authors with additional input from educational experts. The purpose of the survey was to ask a variety of questions to begin to understand what students in grade 7 perceive about the engineering profession. The survey questions and corresponding purposes are shown in Table 1.

Table 1: Survey Questions and Purposes

Number	Question	Purpose
1	What does a doctor do? Can you give an example of work that they do?	Determine the students' knowledge of another profession.
2	What does a teacher do? Can you give an example of work that they do?	Determine the students' knowledge of another profession.

3	What does an engineer do? Can you give example of work that they do?	Determine the students' knowledge of the engineering profession.
4	What do you need to do well to be an engineer?	Determine what students' think is involved in becoming an engineer.
5	Why would someone want to be an engineer?	Determine what the students' think would motivate someone to become an engineer.
6	What is something you do where you are creative or imaginative?	Determine what students' personal understanding creativity and imagination.
7	What does the word design mean?	Determine what students' think design is, what does the word design encompass.
8	Do you know what courses you might need to take in high school to apply to engineering schools for university? Can you give some examples of what these courses may be?	Determine students' knowledge of high school courses required to enter engineering.
9	Do you know any engineers? If yes, how do you know them?	Determine if students have relationships with any engineers that may influence their knowledge.

The survey was tested on a group of students in Ontario in order to insure the clarity and objectives of questions. Responses to the survey generally met the expected purposes, as such no changes to the wording of the survey occurred. There were minor changes to the format and question 8 was also added after the test survey.

Results

The participants included in the preliminary observations are 14 students from the test class, 24 students from Ontario, and 23 students from Alberta. Common observations of the aggregate data are presented below in the form of percentage of responses for each category. Some students presented a variety of ideas in their answers to each question, as such, each idea was coded individually. Individual codes that had a common theme were combined into categories for the presentation of data. Individual codes that were categorized as *other* did not fit in a common theme and also had a low frequency of response (only appeared 1-2 times).

Question 1, "What does a doctor do? Can you give an example of work that they do?" provided 21 ideas with a total of 156 different responses. The aggregate data is shown in Figure 1 below. *Cures* refers to instances where students indicated that a doctor cures illnesses, makes people better, or heals patients. *Diagnosis* refers to instances where students said a doctor would figure out what was wrong with the patient or diagnose them. *Check ups* refers to students indicating that a doctor provides check ups to patients or checks their health. *Helps people* refers to students indicating that doctors help people. *Type* refers to students who described different types of doctors such as a pediatrician, surgeon or psychiatrist. *Works in hospitals* refers to students who described doctors as people who work in hospitals. *Other* included a variety of responses, some examples of which are studies the human body and 'is responsible for their actions'.

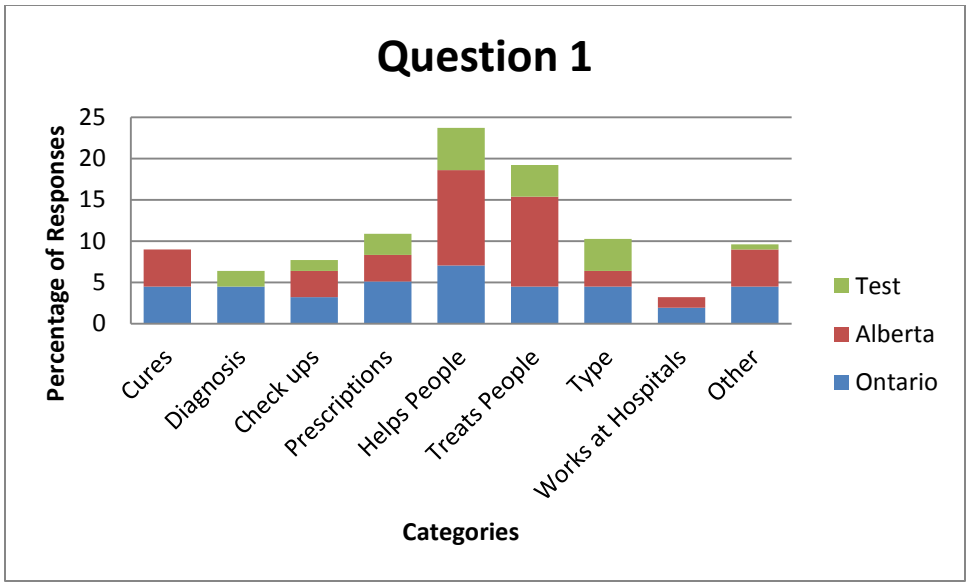

Figure 1: Question 1 Responses

Question 2, "What does a teacher do? Can you give an example of work that they do?" elicited 29 ideas in 119 responses. The aggregate data is shown in Figure 2 below. *Assessment* refers to students indicating that teachers mark them or give them tests. *Helps understanding* refers to answers that indicated teachers help students to understand subjects, help them learn, or help them figure out something they don't know. *Types of subject* refers to students who answered by with describing teachers as teaching subjects (science, French, or math). *For the future* refers to students who indicated that teachers teach things for them to use in the future or later in life, such as learning math to help them in the grocery store. *Teaches* refers to students who simple indicated that a teacher teaches. *Many things* refers to students who responded by saying a teacher teaches many things without specification as to what these were. *Manners* refers to students who indicated that teachers teach students right from wrong or how to behave. *Teach professions/jobs* refers to when students indicated that teachers taught them something for jobs in the future. *Other* includes a variety of ideas, some examples are a teacher works at a school, is a professor, and makes people smart.

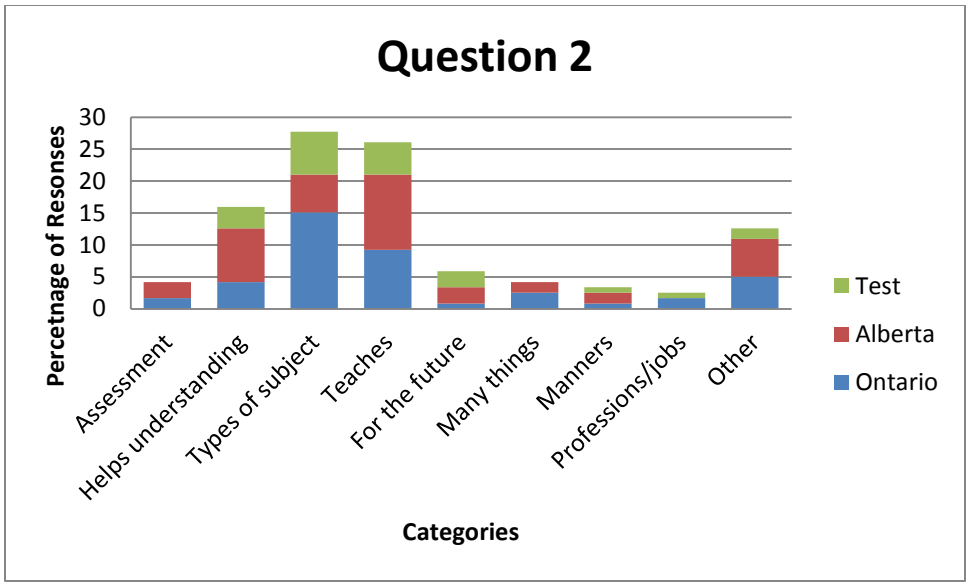

Figure 2: Question 2 Responses

Question 3, "What does an engineer do? Can you give example of work that they do?" gave 36 ideas in a total of 134 responses. The aggregate data is shown in Figure 3 below. *Design* refers to students who indicated that an engineer designs. *Build things* refers to students who indicated that an engineer builds widgets or structures. *Car or mechanical* related refers to students who's answers included something related to cars or mechanical aspects. *Computers/electrical* refers to students who indicated engineers work with computers or electrical components. *Creates* refers to students who indicated that engineers create or imagine things. *Improves life* refers to responses where engineers were helping to better lives or making life easier, for example an engineer might create something to help people with disabilities. *Types of engineer* refers to answers where students listed different types of engineers such as mechanical or aeronautical. *Fixes things* is refers to students indicating that engineers fix items, such as a toaster. *Other* included a variety of answers, such as engineers are concerned with water or an engineer drives a train.

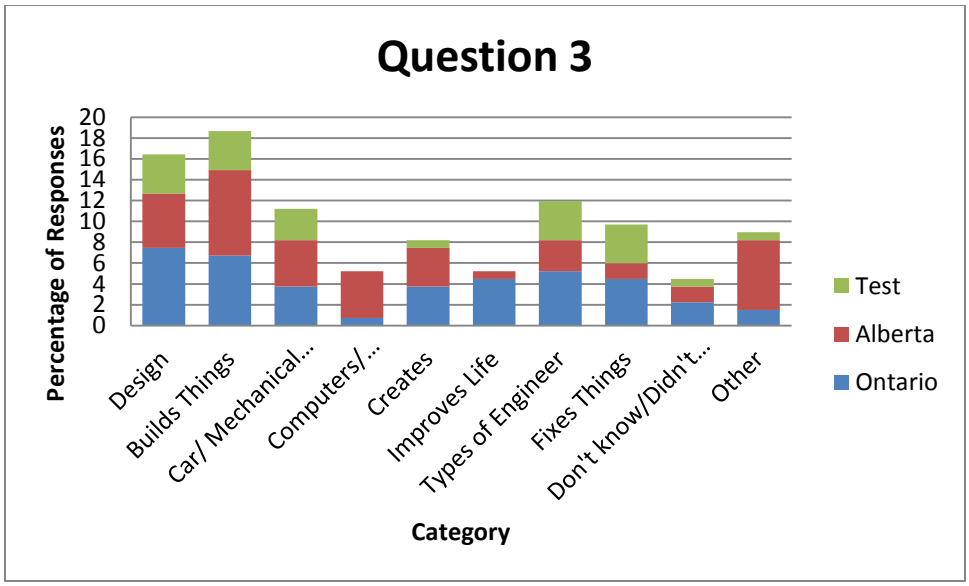

Figure 3: Question 3 Responses

Question 4, "What do you need to do well to be an engineer?" elicited 42 ideas within 112 responses. The occurrence of different categories is shown in Figure 4 below. *Problem solve* refers to students who indicated that engineers solved or analyzed problems. *Human attributes* refers to character qualities that students believe engineers needed to possess, some of these were confidence, curiosity, ambition, and patience. *School/smarts* refers to students who indicated that people would need to study engineering, attend university, or be smart. Students who listed *creativity or imagination* generally did not provide any examples with this, the word creativity or imagination was the only answer provided. *Math* refers to answers that had to do with math, some students referred to math as a subject in general; others provided specific examples such as geometry and algebra. *Science* refers to answers having to do with science; some students provided specific topics such as chemistry and physics. *Other* includes ideas that did not follow a common theme, some examples are know how to read floor plans, welding, and understanding materials.

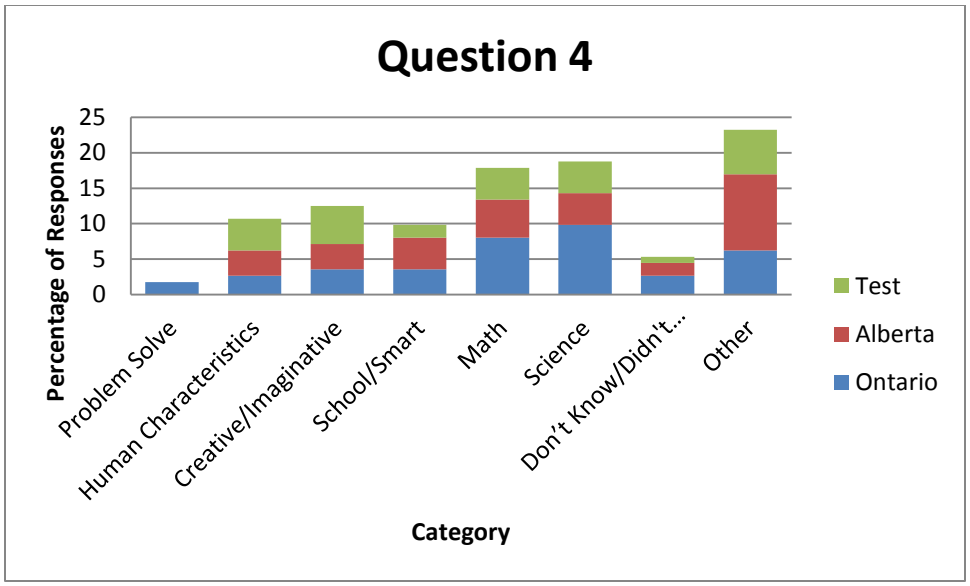

Figure 4: Question 4 Responses

Question 5, "Why would someone want to be an engineer?" provided 40 ideas within 100 responses. Aggregate data is shown in Figure 5. *Building stuff* refers to answers that related specifically to buildings (structures). *Create/ design* refers to answers where students referenced creating or making something. Generally, students just referred to engineers creating something and it being the engineer's creation. *Improve Life* refers to answers that had to do with engineers improving lives, making things easier, or helping people. *Pay* refers to answers where students referenced how much money an engineer would make or what they would be paid. *Like engineering/related topic* refers to students who suggested someone would want to be an engineer because they liked engineering or science. *Job related* refers to answers that related to engineers job being "good", it providing hands on work, or the job being interesting, not related to the pay of the job. *Other* refers to a variety of answers, a sample of these is they want recognition or they like computers.

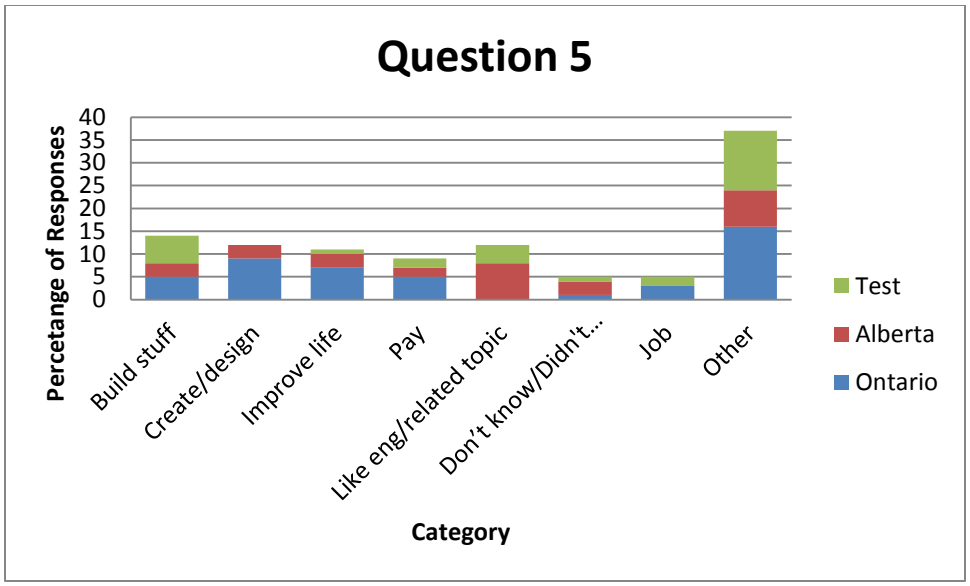

Figure 5: Question 5 Responses

Question 6, "what is something you do where you are creative or imaginative?" provided 28 ideas within 90 responses. Aggregate data is shown in Figure 6. *Lego/building* refers to students referencing building objects with Lego or other materials. *Create/Design* things refers to students who specifically used the words create or design, for example, design clothes. *Active arts* refers to arts where students are moving, for example figure skating or dancing. *Music* refers to activities where students are producing music by playing an instrument or singing. *Reference Other Professions* is where students indicated some professions that might be creative such as architecture. *Write stories* refers to students answering about writing stories, some specifically described them as fiction. *Art* refers to students answering drawing or painting. *Reference engineering* is where students indicated that engineering could be creative. In these responses there was little elaboration as to how an engineer would be creative. *Other* refers to a variety of answers, some examples are dreaming, wood carving and babysitting.

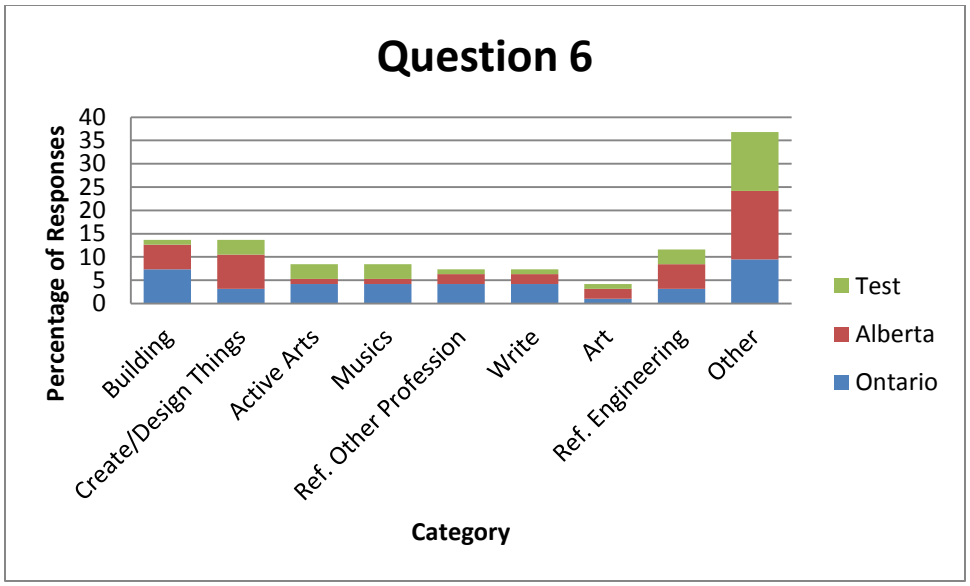

Figure 6: Question 6 Responses

Question 7, "what does the word design mean?" provided 25 ideas with 89 responses. Aggregate data is shown in Figure 7. *Drawings* refers to students who indicated that design meant to draw or make a picture. *Create something* refers to answers where students indicated that to design was to create or make something. *Plan* refers to students indicating that design meant to plan something, for example, blueprints or deciding what something looked like. *Imagine* refers to when students indicated imagining or using their imagination. *Other* referred to a variety of answers; some are a pattern or art.

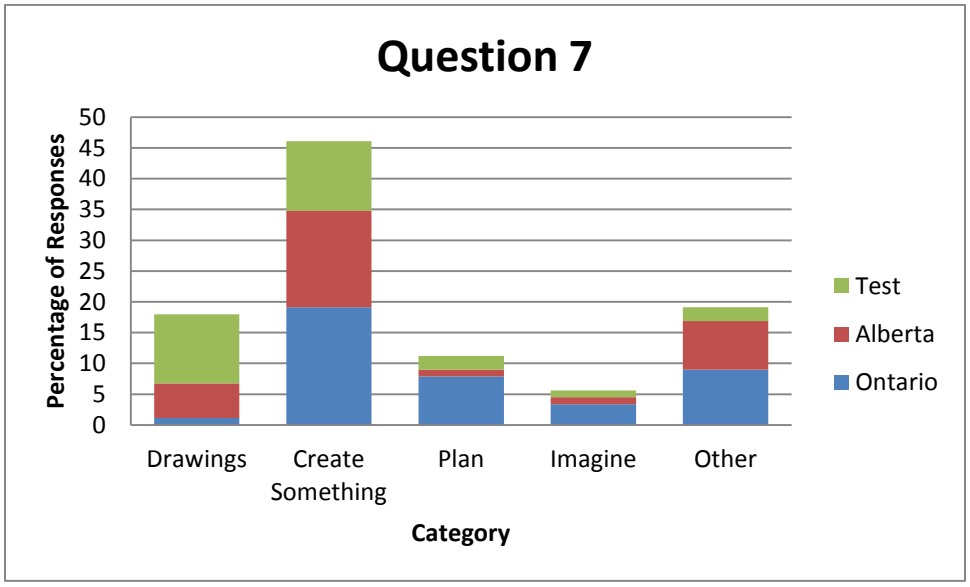

Figure 7: Question 7 Responses

Question 8, "What courses do you need to take in high school?" elicited 8 ideas with 47 responses. For this question, 8 students from Ontario and 23 students from Alberta were surveyed. *Math* refers to students who indicated math in general or a specific math topic such as

algebra. *Science* refers to science in general or students who answered with a specific topic such as chemistry or physics. *English* refers to students who listed English or the language arts, interestingly, only students in Alberta indicated this. *Other* includes engineering and construction as responses.

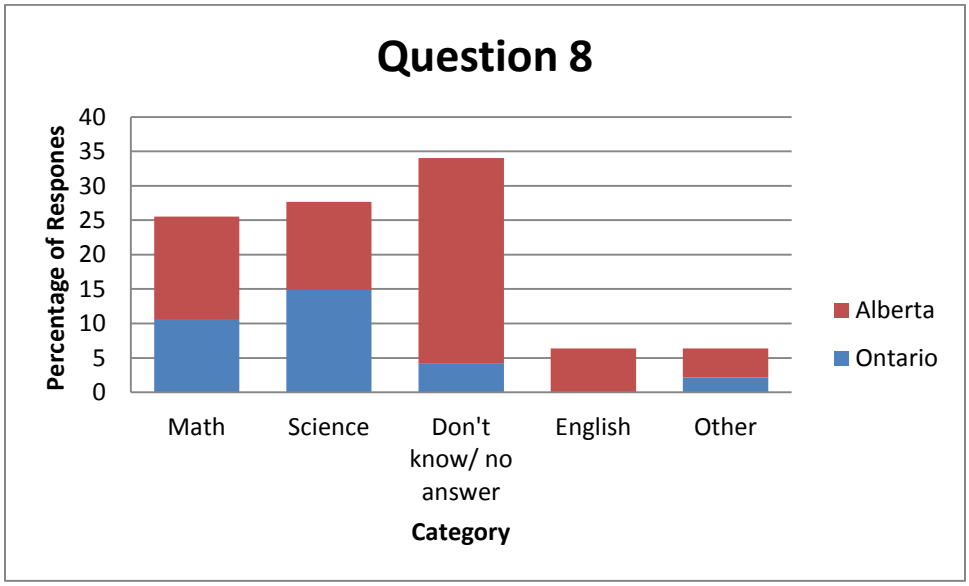

Figure 8: Question 8 Responses

Question 9, "Do you know any engineers?" elicited 5 ideas within 65 responses. *Relative* refers to students who indicated a relative (dad, grandfather) are engineers. *Non relative* are students who indicated a non relative they knew was an engineer (teacher's husband). *Wrong info* refers to students who expanded on their answer of who they knew to be an engineer that led the researcher to believe that individual may not be an engineer, for example, the guy who fixes my car.

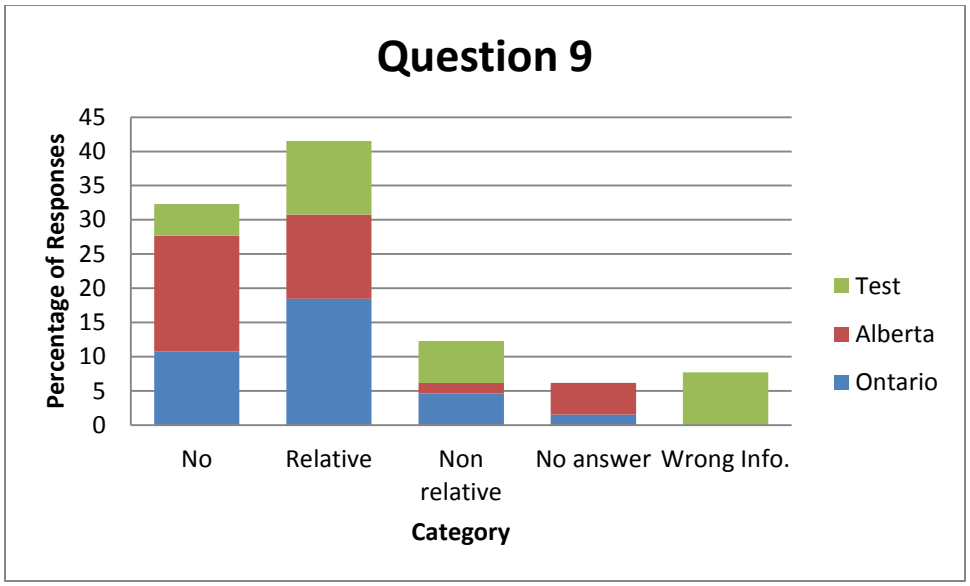

Figure 9: Question 9 Responses

Discussion

This study is limited by the geographic locations of the data as well as the amount of data collected. It is acknowledged that these results cannot necessarily be expanded to the general population based on this initially limited data. However, the trends that are present in the data are presented below.

As seen in questions 1 and 2, students appears to have a better general understanding of the medical and teaching professions than engineering. There are fewer categories present in the definition of both a doctor and a teacher. No student responded that they did not know what a teacher or a doctor did, while some did respond they did not know what an engineer was. This is significant since teaching, medicine and engineering are all relatively common professions.

There appears to be a general idea of the word ‘design’ meaning to create something, with almost 50% of responses noting this. There is also a correlation between students thinking that engineers design and create as well as needing to be creative (question 4), however, there is limited expansion on this idea. Students would suggest that engineers would be creative, but not expand on what that would entail.

In regard to question 5, there are a variety of ideas of why someone would want to be an engineer, without one idea having a majority. This shows that students see a variety of motivations that individuals might have in wanting to pursue engineering.

There is a general idea of what courses you may need to take in high school to be an engineer, however, there are still a number that do not know. It is also interesting to note that only in Alberta did some students note that English would be a requirement.

A number of students know an engineer, many within their own family. Some students expanded on who they knew as an engineer enough that it was questioned if they truly knew an engineer.

It is hoped that as this work continues, the future conclusions will be used to better pair current student perceptions with the goals of activities to introduce students to the engineering profession.

Future Work

Interview questions have been developed to follow up on and further understand the students' perspectives on engineering. These questions further investigate some questions asked on the survey, such as "what does an engineer do", as well as filling in some gaps in the data. For example, several students made reference to engineers needing creativity; the interview will help to further explore this idea.

A sample group of students will be interviewed. These students will be selected based on participant responses to survey questions as well as consultation with the classroom teacher and consent of the parents. Participants will be selected that have a range of engineering knowledge and those who are believed to provide a rich case for the interview.

After the completion of the interviews, they will be transcribed and coded similarly to the surveys. It is expected that the interviews will elicit some new ideas and add trustworthiness to the study by verifying some information in the surveys.

Summary

The research is still in its early stages. The survey has been developed, tested, revised, and distributed to the participants. All survey data to date has been coded and some common themes have been observed in the question responses. Participants will be interviewed in the upcoming months and subsequently this data will be transcribed and coded to add trustworthiness and value to the study.

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