Southern Regional Hub-funded project

Project Report

Initial Teacher Education (ITE) students' perceptions of typical engineers: Assessing potential for bias in the formative career decision years

Compiled by Paul D. Docherty and Wendy Fox-Turnbull with contributions from Pinelopi Zaka and Tessa Impey

September 2020

Ako Aotearoa

The University of Waikato
Te Whare Wānanga o Waikato

UC University of Canterbury
Te Whare Wānanga o Waitaha
Christchurch New Zealand

Associate Professor Docherty and Ms Impey are with the Department of Mechanical Engineering, University of Canterbury, Christchurch, New Zealand

Associate Professor Fox-Turnbull is with the School of Education, University of Waikato, Hamilton, New Zealand

Ms Zaka is with E-Learning Support, University of Canterbury, Christchurch, New Zealand

Please direct enquiries to either paul.docherty@canterbury.ac.nz or wendy.fox@waikato.ac.nz

This project was funded through the Ako Aotearoa Regional Hub Project Fund. More information is available at: https://ako.ac.nz/knowledge-centre/investigation-of-initial-teacher-education-student-views-of-engineers-and-engineering-practice/

Ako AOTEAROA

An Ako Aotearoa publication. This project output has been funded by Ako Aotearoa through the Regional Project Fund.

This work is published under the Creative Commons Attribution-NonCommercial-Share Alike 4.0 International License (CC BY-NC-SA 4.0). Under this licence you are free to copy, distribute, display and perform the work as well as to remix, tweak, and build upon this work noncommercially, as long as you credit the author/s and license your new creations under the identical term.

Abstract

There is a recognised lack of female participation in most engineering and STEM related careers. However, it is desirable for engineers to have a variety of characteristics including those typically considered feminine. These traits include empathy and heightened consideration of social and moral issues. Therefore, girls need to be encouraged into all engineering fields, but especially those traditionally dominated by males such as civil, mechanical and software engineering.

Students between the ages of 11-13 years make critical decisions related to career choice. A number of factors influence students' career choice. Teachers influence their students in a number of different ways, some overt and others subliminal, including influencing students' self-image and belief in capability. Students between the ages of 11-13 years often develop images of themselves that subsequently excluded them from careers in technology related careers such as engineering.

This study used qualitative data in an attempt to understand student primary teachers' perceptions of engineers, engineering and students who may become engineers. The results indicated that most final year teacher-education students held either limited or stereotypical views of engineering and engineering related careers. Participants thought of engineers as mainly male or "country-type" girls who were good at maths and science. Most recognised the practical nature of engineering, some the academic nature. There was little recognition of the social, empathetic and nurturing characteristics required. This Ako Aotearoa funded study aims to contribute to understanding the gender imbalance in engineering by highlighting soon-to-be teachers' views of the profession and the people who are working within it.

Key Words: Engineering education, teachers' perceptions, career selection

1 Introduction

1.1 Background

Due to the new challenges of today's complex world, engineering practice is changing. An increasing number of issues such as economy, culture, sustainability and society need to be considered when solving engineering problems. To assist catering for these complex issues engineering practice needs to change. Collaboration, creativity, analytical thinking, knowledge sharing, and interdisciplinary thinking and practice must be added to 'traditional' engineering knowledge and skills (Du & Kolmos, 2009). Non-diverse professions miss out valuable contributions and new ways of approaching problems that a varied workforce brings (Schäfer, 2006). We can therefore conclude that diversity among engineers is highly desirable. How can this be accomplished?

Many influences cause young people to reject engineering as a potential career (Dasgupta & Stout, 2014; C. Hill, Corbett, & St Rose, 2010; Weber, 2012; Weber & Custer, 2005). However, research has shown that these influences tend to be psycho-social rather academic (C. Hill et al., 2010; Lloyd, Gore, Holmes, Smith, & Fray, 2018). Hence, when determining how to achieve diversity in engineering the assessment of various factors of influence on self-perception needs careful consideration. The influence of educators during early adolescence has been noted to have an effect on career decisions (A. Bandura, C. Barbaranelli, G. V. Caprara, & C. Pastorelli, 2001; Di Nardo et al., 2006; Low, Yoon, Roberts, & Rounds, 2005), assessing the effects of educator influence offers potential for rectifying the lack of diversity in engineering. Therefore, determining whether teachers of early adolescents have false opinions of engineering practice allows a unique ability to design and deploy specific educational policies to rectify or ameliorate the problem identified.

Teachers play a role in career selection of their students. While it is acknowledged that parents and family values have the greatest influence (Kazi & Akhlaq, 2017; Lloyd et al., 2018), teachers and educational settings are also

recognised as playing a role (Kazi & Akhlaq, 2017; Krumboltz, Mitchell, & Jones, 1976). There appears to be consensus that academic achievement and perceived academic ability also influence students' career selection (Kazi & Akhlaq, 2017; Krumboltz et al., 1976; Lloyd et al., 2018). Kazi and Akhlaq (2017) state that students should not be forced or pushed into careers that they do not want to enter, however they also identify that students often make career decisions with limited knowledge of the real world, thus students are making life-changing decisions when not fully informed. It is therefore vital that those who influence students' career selection have accurate representations of these careers.

The goal of this research was to elucidate whether the teachers of children aged 11-13 years have accurate perceptions of engineering and engineers, given the influence they have on career selection. In New Zealand, where this research took place, there are four main stages of education – early childhood, nominally for children from 0 to 5 years old, primary for 5 to 12 years old, secondary for 13 to 18 year olds, then tertiary education for those over 18. Thus, this research investigated the perceptions of engineers and engineering related careers by primary teacher education students in their final year of training. The main research question was "What are final year primary teacher education students' perceptions, attitudes and beliefs about the dispositions, knowledge and skills needed for students who enter engineering related practice and careers when leaving school?

To maintain focus, this project only considered professional engineering. The project did not consider engineering as a trade. While trade-engineering this is an import field, and one that has similar gender imbalance to professional engineering, consideration of both was considered too large of a project. Furthermore, ameliorating imbalance in professional engineering would have the greatest potential effect in achieve upwards social mobility of marginalised groups.

1.2 Literature Review

This literature review investigates three main areas. Stereotypical views of engineers and engineering, the importance of having a diversity workforce in all aspects of engineering careers and the role teachers play in career selection for early adolescent children.

1.2.1 Stereotypical Views of Engineers and Engineering Related Careers

Common perceptions about engineers include that they need to be critical analytical thinkers, good at maths and science, highly pragmatic, practical, with secondary requirements for logical thinking, empathy and effective communication, (Godwin, Potvin, Hazari, & Lock, 2016). While these skills and attributes are present and desirable in or for engineers, the modern professional engineer requires a much broader set of skills (legal, ethical, ergonomics, client support, documentation for liability mitigation, and excellent written communication skills).

Another common perception is that engineers are mainly male in a male dominated field (Barnard, Hassan, Bagilhole, & Dainty, 2012; Reilly, 2012; Weber, 2012; Weber & Custer, 2005). Weber (2012) found that the females in her study did not become engineers, regardless of their abilities in maths and science, and may have based their decisions on stereotypes, thus instigating stereotype threat. According to Spencer *et al.* stereotype threat occurs when:

> members of a stigmatized group find themselves in a situation where negative stereotypes provide a possible framework for interpreting their behaviour, the risk of being judged in light of those stereotypes can elicit a disruptive state that undermines performance and aspirations in that domain (Spencer, Logel, & Davies, 2015, p. 1).

When exposed to stereotypical views, a person can feel threatened because of the often-negative behaviour associated with the stereotype or the pressure to perform said behaviours. Stereotype threat affects women who identify with the domain of engineering (Cadaret, Hartung, Subich, & Weigold, 2017).

Despite considerable effort to attract females into engineering, the profession is still male-dominated. Barnard et al. (2012) identified that parental and peer support to enter engineering was particularly important for girls to overcome the stereotype and engage in engineering. Other factors influencing girls' decision to enter into engineering were close contact with engineers as family members and recognition from parents that maths and science were critical subjects for their education. The Barnard et al. (2012) study also found that once girls entered engineering, experiences were mixed. Some found their gender an advantage, especially when working collaboratively with peers. Others found it a distinct disadvantage and experienced negative gender prejudice.

Stereotypical views are a barrier to female participation in engineering (Cheryan, Master, & Meltzoff, 2015; Dresden, Dresden, Ridge, & Yamawaki, 2017). Cadaret et al. (2017) states that stereotypes act as a threat to self-efficacy, which plays a role in career selection, particularly for females. Before further discussing the role that self-efficacy and teachers play in career selection, consideration of diversity in the engineering profession is necessary. Why is it important to have women and other minority groups represented?

1.2.2 Diversity

Stereotypical prejudices of engineers and engineering influence which individuals seek out careers in the field and thus ultimately lead to the poor diversity in engineering practice (Ahmed, Basantis, & Jahan, 2019; Barnard et al., 2012; Dasgupta & Stout, 2014; C. Hill et al., 2010; Weber, 2012; Weber & Custer, 2005). There is a recognised lack of diversity within most engineering disciplines, especially for women and minority groups. In New Zealand, a study on girl's attitudes to engineering found that marketing materials for engineering qualifications used by Institutes of technology and polytechnics had poor representation of images of women (E2E, 2019). The disparity not only contributes to income, social status and social-mobility discrepancies, it perpetuates the stereotypes identified above. Increasing diversity within engineering is very important as global problems are becoming increasingly

complex (Cadaret et al., 2017; Godwin et al., 2016). Gutierrez, Paulosky, Aguinaldo, and Gerhart (2017) suggest that as more and more women enter the engineering profession they begin to shape the direction of the field. A diverse workforce facilitates identification of more opportunities; increases ways of viewing new opportunities; enables greater complexity of ideas and the recruitment of a wider range of resources. Diverse ideas and different ways of seeing the world enable a wider range of potential solutions. Varied and diverse perspectives and experiences also better facilitate the addressing of unpredictable needs of the future (Gutierrez et al., 2017).

Even when selecting a career in science fields, girls tend to gravitate towards humanity related professions such as medicine and health (Koppel, 2002). Those girls who enter engineering have a slight tendency to move into disciplines within engineering that are perceived to be more socially and environmentally aware such as environmental and biomedical engineering. To combat this, engineering courses need to deploy non-biased gender neutral pedagogies such as problem solving and collaborative and team work approaches (Gutierrez et al., 2017; Koppel, 2002) and include humanities and non-technical aspects to their course (Nguyen, 2000). Another potential way to combat this is to have teachers understand accurate accounts of engineering as they influence their students' career choices. In their research on New Zealand teachers' perceptions of introduced computational thinking in the Primary school curriculum, Duncan, Bell and Atlas (2017) found that some teachers had misconceptions about the computer science field. Duncan et al. (2017) note the importance of addressing these teacher misconceptions through appropriate professional development so that teachers are able to pick up and address students' own misconceptions. The Computer Science Unplugged project provides a wide range of resources for teachers on teaching computer science to students from as early as 5 years old and has been used for teachers' own professional development on computer science (Duncan et al., 2017). An engineering education to employment project, the Waikato-Tainui partnership, aimed to support secondary school students and their teachers, while working together with Māori engineers (E2E, 2019). The school-Wintec programme provided professional development to teachers and

the Unitec led partnership between engineering firms and schools created opportunities for collaborative creation and delivery of courses leading to entry to tertiary engineering programmes (Vaughan, 2018).

1.2.3 Teachers Role in Career Selection

Lamb et al. (2017) identify three key influences on career choice in Science, Technology, Engineering and Mathematics (STEM) related careers: positive attitudes and interests, self-efficacy and persistence; appropriate soft skills and stable tendencies related to cognition. Teachers could potentially have ability to directly influence the broad career selections of their students. Teachers ultimately have a high level of influence on their students self-perception, self-image and perceived capability, therefore indirectly influencing students' perceptions of their abilities, their self –esteem and efficacy and ultimately career selection.

Prior research infers that children aged 11-13 years students make critical decisions about their future careers (Jones, Taylor, & Forrester, 2011; Lamb et al., 2017; Low et al., 2005). A number of researchers have found that at this age children are influenced away from considering careers in engineering by their perceptions, attitudes and beliefs about the scope and components of engineering related practice and careers and their perceived abilities in maths and science (Ahmed et al., 2019; Godwin et al., 2016; Weber & Custer, 2005). However, this choice is typically implicit rather than explicit – they are choosing what parts of the curriculum to identify as their strengths, and not necessarily considering the careers this may lead to. Teachers have a known influence in students' thinking and career selection (Kazi & Akhlaq, 2017; Krumboltz et al., 1976; Lloyd et al., 2018). This influence can occur through a range of avenues. Importantly, the enrolment rate of females in engineering has been linked to the way in which the profession is presented to students while at school (Nguyen, 2000). Literature suggest that teachers influence female students' decisions to enter (or not) engineering related careers in three ways, summarised in Table 1 and detailed in this section.

In her 2012 study, Weber (2012) found that traditional technology education activities with a focus on technical and mechanical skills and concepts were mostly likely not appeal to females and subsequently prevent them from enrolling in other technology and engineering related courses, thus we can see teacher influence student through their course design.

Koppel (2002) suggest that career influence may come from the way in which teachers talk about careers. Positive teacher attitudes, emphasising the importance and usefulness of engineering and science caused positive change in the likelihood of selection career of their students in Weber and Custer's (2005) study. Other important factors teachers need to emphasise are the social and cultural impacts of engineering related products thus potentially fostering a connection with their female students, increasing the likelihood engineering selected as a career option. Interventions such as these have proven to affect changes in students' perceptions of careers (Mitts & Haynie III, 2010; Weber & Custer, 2005). Well-known factors in the identification of outstanding teachers include high expectations, enthusiasm and teacher knowledge and pedagogical knowledge (Banks & Mayes, 2001; M. Hill & Thrupp, 2019; Jeanpierre, Oberhauser, & Freeman, 2005; Weber & Custer, 2005). It is therefore logical to conclude that teachers' attitudes, knowledge and talk about engineering directly and indirectly influence their students' views about engineering.

Teachers' factors of influence	Summary of influence
Existing course design and pedagogy	Courses that are technological and skills based discourage female enjoyment and enrolment in subsequent courses
Attitudes towards Engineers	Speaking about engineers and engineering to either perpetuating or dispelling stereotypes
Students' self-efficacy	Teachers comments, actions and biases influence students' sense of self and therefore their belief about potential future careers

Table 1: Teachers Influences of Female Selection on Careers in Engineering

Self-efficacy (ability to exhibit coping behaviours and resilience) is a critical factor in career selection (A. Bandura, C. Barbaranelli, G. Caprara, & C. Pastorelli, 2001). Through self-efficacy self-belief develops. In their study on identity and critical agency in engineering career selection Godwin et al. (2016) state that understanding student identity and self-efficacy are valuable for guiding them to STEM related careers. Students' perceptions of their ability and self- efficacy, no matter how accurate can turn individuals off particular careers (Cadaret et al., 2017; Krumboltz et al., 1976). This is particularly relevant within the fields of science, technology and mathematics. Students' achievement in these subjects influences whether or not to consider a career in engineering and related careers (A. Bandura et al., 2001).

In order to attract more females into engineering disciplines, initiatives including systemic support to nurture, protect, and encourage girls, in particular, to pursue careers in those fields that have been traditionally male-dominated.

Teachers need to be more responsive, sympathetic and supportive when engaging with female students with an eye to encouraging more to study engineering (Nguyen, 2000). It is imperative that girls recognize that engineers do have a positive impact on the world and its inhabitants. To do this, teachers need to be knowledgeable and informed about engineering. To do this their initial understandings need to be identified.

2 Methodology and Methods

The studies in this report were framed through a constructionism epistemological stance, as identified by Crotty (1998) as the understanding that individuals construct meaning through their experiences, the tools they use, the networks of people they engage with thus constructing knowledge through interactions with others within a socio-cultural environment. This is underpinned by Vygotsky's (1978) social cultural theory within which cognitive development is dependent upon an individual's responses to cultural and societal influences.

The general overarching hypothesis assumed that primary teacher education students tend to have a view that engineers are overly pragmatic with good technical skills, but lack empathy or strong communication skills. It was expected that primary teacher education students would have moderate understanding of engineering practice, and that while they would be aware of the bias in gender participation in STEM, they would not exhibit any personal prejudice in this regard.

This study used dual qualitative and quantitative approaches. This design was intended to achieve effective triangulation.

2.1 Brief description of investigator backgrounds

Four investigators led different aspects of the analysis and coding and each used slightly differing approaches. Furthermore, each investigator had significantly different backgrounds and bias leading into the primary analysis. However, all conclusions from each analysis was checked by all named investigators.

Associate Professor Paul Docherty undertook the primary analysis of Section 3.4. He has a BE mechanical, and a PhD from the University of Canterbury, where he is currently an academic. He worked as a qualified tradesman, but has only

limited experience as a professional engineer. He has taught in many domains and levels from preschool ministry in a church setting, various sports (soccer, taekwondo, boxing), undergraduate and PhD level engineering and numerical analysis. He has a tendency to favour the constructivist theory of cognitive development. This bias may lead in increased interest in quotes that indicate an experiential development of attitudes and believes.

Associate Professor Fox-Turnbull led the analysis in Sections 3.2 and 3.3, and contributed significantly to Sections 3.1 and 3.4. AP Fox-Turnbull is currently deputy HOS education at the University of Waikato with a particular research interest in technology education and teacher education. She is also a trained primary school teacher who taught for 12 years before joining staff in the initial Education Programme (ITE) programme at the then Christchurch College of Education current College of Education at the University of Canterbury. She was worked in this sector for the past 23 years, the last three at the University of Waikato. She undertook the current research from a constructivist paradigm. Analyses of section 3.2 and 3.3 were aided via use of the NVivo software.

Pinelopi Zaka undertook the primary analysis of Sections 3.6 and 3.7. She is an advisor of Flexible teaching and learning for academic staff at the University of Canterbury. She has worked as a teacher in Primary classrooms, as a Science and Technology Educator in Primary and Secondary schools and as a teacher trainer of Science and Technology. She has been involved in (mainly) qualitative research in the field of e-Learning and digital technologies in primary, secondary and tertiary education. Her approach as a researcher and professional is underpinned by constructivism, which acknowledges the importance of the learner's own experiences in shaping their understanding of the world.

Ms Tessa Impey guided the analysis of section 3.1. She is in her honours year in mechanical engineering at the University of Canterbury. She is working towards a minor in biomedical engineering and a diploma in global humanitarian engineering alongside her honours degree. She has a specific interest in the influence of the current education system on students in our modern society.

She conducted her analysis using sociocultural theory as her research framework as she believes individuals are heavily influenced by the cultures in which they live.

2.2 Qualitative investigations

The qualitative approach included individual structured interviews with 20 primary teacher education students from two New Zealand universities (ten from a North Island University and ten from a South Island University) and two of their lecturers, one from each university. Ethical approval was granted by the University of Canterbury Ethics committee and the University of Waikato Division of Education ethics committee. Interviewees were recruited via emails send from the investigators to specific class lists that captured the desired cohort. At both centres, there were initially insufficient responses and follow-up emails were required. Interviewees were a mix of students in their final year of a three-year undergraduate degree or graduates undertaking a one-year graduate diploma in teaching and learning and two staff who lectured in technology. Table 1 outline demographic data gathered. Of the twenty students, three declared that they were male. Anecdotally, this is not an unexpected ratio of males to females in primary teacher education programmes in New Zealand. The students ranged in age from 20 to 60+ years. One lecturer was over 60 and the other within the 35-60 age range. To preserve interviewee anonymity, the interviewees and their ages have been decoupled. To preserve anonymity, interviewees were given pseudonyms in the interview. However, these were updated in this report codes including a letter designating self-identified gender (M/F) and an arbitrarily assigned number from 1-22. The letter 'L' was added to indicate the lecturers.

Age in Years	**15-22**	**23-35**	**35-60**	**60+**	**total**
Lecturers			1F	1F	**2F**

Students	6F	2M, 7F	1M, 3F	1F	**3M, 17F**

Table 2: Demographic Information (F = female M=male)

The semi-structured interviews aimed to determine the interviewees' views of engineering, and their views of the characteristics of children they believed might become engineers. All interviewees volunteered and gave informed consent. Interviews took between 30-55 minutes. To increase reliability and avoid interviewee bias, interviewees were told the study was to determine their views about a range of careers, rather than specifically engineering. The information sheet and informed consent signed by the students can be seen in the appendix. The initial stage of the interviews concentrated on the interviewees own interests and goals. This was intended to background information that may enable a lens to understand the interviewee's later responses. This section was followed by questions about other occupations so the following questions specifically about engineering did not disengage the interviewees. These questions asked specifically about engineering culture, practice, and reasons for the imbalance of female, and Māori and Pasifika participation. Finally, some demographic data was obtained.

Again, to improve the reliability of the data, students and their lecturers from two universities were interviewed. In this research, a formal definition of gender was not presented to the interviewees. It was felt that it was appropriate for interviewees to respond according to their own definitions of gender. However, the investigators interpreted the interviewees' responses as though the interviewees were considering the gender presentation as it would be observed at the time considered. Transcribed interviews were analysed, coded, and recoded using a thematic approach to identify key themes. The interview script and format is shown in Section 2.2.1

2.2.1 Interview format

1 Introduction

1.1 Introduction of Researcher and overview of project We are undertaking a research project investigating teachers' influences on career choice in Children Ages 11-13. Prior research suggests that educators have a very high level of influence on the self-perception of children in this age group. The goal of this project is to determine influences in career choice. This interview should take 30-45 minutes.

1.2 Tell us about where you come from and a little about your background? *(urban/rural background)*

1.3 What occupations do/did your parents or primary caregivers have?

1.4 Consider the person or people in your life who was/ were most influential in you deciding to be a teacher

1.5 What was it about them that encouraged you in this direction?

1.6 Tell me about your professional goals and the part of teaching interests you the most?

2 Students

2.1 In your mind, please imagine the 12-year-old that you would recommend a career in teaching. Describe that person to me by identifying the top 10-20 characteristics they would ideally have and why?

2.2 In your mind, please imagine 12-year-old that you would recommend consider a career in Medicine. Can you describe them to me?

2.3 In your mind, please imagine 12-year-old that you would recommend consider a career in Law. Can you describe them to me?

2.4 In your mind, please imagine the 12-year-old that you would recommend a career in Engineering. Can you describe them to me?

2.5 Literature and anecdotal evidence suggests that female numbers are low in engineering. Why do you think technically minded females tend to pursue non-STEM professions?

2.6 Literature and anecdotal evidence suggests that Māori/Pasifika numbers are low in STEM fields. Why do you think technically minded Māori/Pasifika students tend to pursue non-STEM professions?

2.7 Who do you think has the most influence of children's aged 11-13 career choice

2.8 What role do teachers play in this decision?

3 Engineering

3.1 What is engineering?

3.2 What do engineers do? Tell us about your understanding of their:
- 3.2.1 the technical tasks
- 3.2.2 communication tasks, writing reports /discussions
- 3.2.3 social tasks.

3.3 What is your understanding of 'engineering related careers'?

3.4 Name careers that you think would fit into this category.

3.5 Tell me about any experiences that you have had with engineering related careers.

3.6 What type of people become engineers? Why?

3.7 If you were a cartoonist and asked to draw the "Typical Engineer" what would it look like?

3.8 Explain your understanding of the relationship between technology education and engineering.

3.9 What do you imagine might be the hurdles to a good engineering solution/design?

3.10 What is likely to be the greatest hurdle? Why?

3.11 Did you ever consider a career in STEM? (Science technology engineering mathematics)
- 3.11.1 If so what put you off the option? Why/When?

4 Demographic Information

4.1 What age range do you fit into

15-22, 23-35, 35-60, 60+

4.2 What is your gender?

4.3 Have you had previous career? If so what?

Interview question strategy

Of note, the more important questions were located in the second half of the interview. The initial stages of the interview were intended to obtain important background information to enable contextualisation of the interviewees' later responses. They were also asked to speak about themselves and their goals initially to encourage rapport with the interviewer and further enhance contextualisation of the interviewees' motivations.

The study could potentially have been broader and included career recommendation prejudice among other communities with a low participation in engineering. These communities may include rainbow communities, immigrant communities, ethnic minorities, those with low socio-economic status and the disabled community. However, this study was designed partly in response to concerns within the engineering profession and engineering education providers regarding low female, Māori and Pasifika representation in engineering.

All interviewees engaged well with the interview process. This may have been due to a variety of factors such as: the successful interview design; the general tendency for student teachers to be talkative; selection bias for those who responded to take part in an interview; and/or possibly a sense of responsibility to engage in research. We could not determine the relative strength of these factors.

2.2.2 Key research questions

The named investigators each considered specific elements of the student responses. The investigators chose to concentrate on domains that suited their interests and research strengths, but also ensured the most pertinent matters were well considered. Table 3 shows the various research questions reported in Section 3.

Question	Investigator(s)	Section
What are the interviewees understanding of engineering as a profession?	Ms Impey with contributions from Dr Fox-Turnbull	3.1
What characteristics do interviewees think an engineer is likely to have	Dr Fox-Turnbull	3.2
What characteristics would the interviewees look for when considering recommending a career in engineering to children	Dr Fox-Turnbull	3.3
How were ITE students influenced in their career choice? And how does this compare to their view of the influences on students?	Dr Docherty with contributions from Dr Fox-Turnbull	3.4
Why do student teachers think there is a lack of female representation in Engineering and STEM fields?	Ms Zaka	3.5
Why do student teachers think there is a lack of Māori and Pasifika representation in Engineering and STEM fields?	Ms Zaka	3.6

Table 3. Key research questions

2.3 Quantitative analysis

The quantitative analysis included a questionnaire that was delivered over the internet. The questionnaire format is shown in section 2.3.1. The 'Google forms' survey platform was used as it offered sufficient anonymization and accessibility. Eligible students and staff were invited to engage in the survey via two emails. In total 50 students from each university were desired. The questionnaire was focussed towards engineering practice.

The call for interviewees was undertaken after the interviews of the qualitative analysis. This was to ensure that interviewees of the qualitative interviews did not know that the investigators were interested in engineering. Hence, this minimised selection bias in the interviewees of the qualitative analysis.

2.3.1 Questionnaire format

Part A: Instructions

Please tick your response to the following statements about importance of specific traits for engineers, with 1 being unimportant and 7 being very important.

How important is it for an engineer to be:	Unimportant						Very important
Intelligent	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Physically strong	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Physically fit	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Good with hand tools	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Technically minded	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Analytical	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Creative	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Artistic	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Musical	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Inquisitive	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Ethical/moralistic	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Empathetic	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Eloquent	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Patient	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Humble	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Logical	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Legalistic	1☐	2☐	3☐	4☐	5☐	6☐	7☐
A natural leader	1☐	2☐	3☐	4☐	5☐	6☐	7☐
A good follower	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Studious	1☐	2☐	3☐	4☐	5☐	6☐	7☐
A good verbal communicator	1☐	2☐	3☐	4☐	5☐	6☐	7☐
A good written communicator	1☐	2☐	3☐	4☐	5☐	6☐	7☐
A good diagrammatic communicator	1☐	2☐	3☐	4☐	5☐	6☐	7☐
Able to interpret complex instructions	1☐	2☐	3☐	4☐	5☐	6☐	7☐

Part B: Instructions
Please complete the following sentences.

Engineers need strong	☐ Mathematics abilities ☐ English abilities

	☐ ability in both English and Mathematics ☐ ability in neither Maths or English skills
Engineers should ideally be	☐ Intellectual ☐ Empathetic ☐ Intellectual and Empathetic ☐ Neither Intellectual nor empathetic
Engineers are typically	☐ Extroverted ☐ Introverted ☐ Both Extroverted and Introverted
Please rank the importance of the following disciplines to indicate who may be a successful engineer (1- most important, 9 least important)	____ Drama ____ English ____ Mathematics ____ Physical Education ____ Physical Science (Physics/chemistry) ____ Social Studies ____ Technology ____ Visual Art
Please define the percentage of time that a typical *early career* engineer would spend in the following tasks	____ Technical analysis ____ Written communication ____ Interpersonal communication
Please define the percentage of time that a typical *late career* engineer in the following tasks	____ Technical analysis ____ Written communication ____ Interpersonal communication
Please try to list 5 personality traits that might describe a typical engineer	
I type of subjects that I have the greatest personal preference to teach into are	☐ Creative arts, or music ☐ English, language, or drama ☐ Mathematics ☐ Science and technology

Declaration: I fairly considered all questions in this survey and answered all to the best of my ability.	☐ Yes ☐ No
I understand that the data generated by this survey will be collated and published, but that my identity will never be associated with my responses.	☐ Yes ☐ No

I am a	☐ Male ☐ Female	☐ Student ☐ Academic	and aged	☐ 18-22 ☐ 23-35	☐ 36-60 ☐ 60+

2.3.2 Quantitative outcome

Unfortunately, only 12 students engaged with the survey despite the initial and follow-up email. Furthermore, preliminary interpretation of the survey showed that it lacked ability to gain any insight from the students that could enable presentation of novel, or even interesting findings. Hence, the results of the survey were disappointing in terms of their benefit to the overall project. The interviewee responses that could not enable effective support, contradiction or nuance for the themes that emerged from the responses from the qualitative analysis. Hence, the results of the survey were abandoned and the intended triangulation strategy had to be revised.

2.4 Revised triangulation strategy

Triangulation is a very important element of providing scientific validity to qualitative research. Due to the ineffective outcomes of the quantitative analysis, a new triangulation strategy was deemed necessary.

For each analysis, a lead investigator worked through all of the transcripts to determine quotes relevant to their research question. The interpretation of the quotes was undertaken in isolation from the other investigators. The primary interpretation was then blinded and the other investigator made their own independent interpretation of the quotes identified by the initial investigator. The individual interpretations, including the primary interpretation were then compared and full consensus across the investigators was sought before the interpretation was recorded.

3 Findings

In general, the qualitative results revealed quite limited and traditional views of engineers and engineering from the initial teacher education (ITE) students. The following sections elucidate the interview interviewees' understanding of engineering practice, their perception of professional engineers, who they think should be recommended a career in engineering, who they think influences students and the reasons they think there is low female, Māori and Pasifika participation in engineering.

3.1 The understanding of engineering and engineering culture among interviewees

3.1.1 Definitions of engineering

Prior to interpretation of interviewees understanding of engineering, an accurate definition should be provided as a benchmark. The definition provided by the Lexico online dictionary, (a branch of the Oxford dictionary) is:

> 1. The branch of science and technology concerned with the design, building and use of engines, machines, and structures
>
> > 1.1 The work done by, or the occupation of, an engineer.
> >
> > 1.2 The action of working artfully to bring something about. 'if not for Keegan's shrewd engineering, the election would have been lost.'
>
> Lexico online dictionary (Oxford dictionary)

However, the researchers feel that the primary definition is archaic and only considers civil and mechanical branches of engineering. The definition fails to encompass post 1900 elements of engineering such as chemical engineering and electrical engineering. Further more modern, post 1980s examples include mechatronics engineering, bioengineering, and financial engineering. The

authors deemed genetic engineering to be a discipline founded in biology, and not engineering. While there are elements of core engineering philosophy and practice in genetic engineering, it was deemed outside of engineering due to the different training, knowledge base and culture. The secondary definition (1.1) must be considered as an indication of an appropriate alternative use for the word, rather than a definition. If considered a definition, it would seem somewhat circular. The tertiary term (1.2) seems to provide a further alternative use for the word outside of its use to describe elements of the occupation, and thus is not relevant to this research.

The dissatisfaction with the formal dictionary definition led the researchers to provide some alternatives. The engineers in the research group considered their own definition prior to conducting their analysis and asked some senior engineers for their definitions. Only the titles of the senior engineers are reported.

> The process of using appropriate mathematical, scientific and ergonomic concepts in the development and maintenance of structures, devices, or systems that achieve the goals of the benefactor.
>
> Dr Docherty (author)
> Associate Professor in Engineering,
> New Zealand

> Using mathematics and science alongside critical thinking and creativity to design and build effective solutions to problems.
>
> Ms Tessa Impey (contributing author)
> Honours candidate in Engineering,
> New Zealand

> Engineering is the creation of solutions to complex problems, by the production of technical artefacts. Its mechanisms for doing this are to use design methods as the creative element, the sciences as the basis for analysis, and the management of organisations for the operational element. The strength of engineering is the integration of these work streams to provide solutions that are novel and holistic. This is worth doing because of complexity in the problems, which typically arise from coupled interactions, conflicting expectations of multiple

> stakeholders, risk of adverse consequences for well-being of people and the natural environment, and lack of obvious solution for infrequently encountered issues.
>
> Ex-Dean of Engineering, University New Zealand

> Making something work using physical principles, or maybe not using physical principals. It doesn't matter how the thing works, so long as it works.
>
> Director of a Medical Research Institute Germany

One may summarise these definitions to redefine engineering via the following points:

- Engineering is concerned with generating and maintaining products. The products are generally physical, but not necessarily.
- Knowledge of science and mathematics should underpin engineering product development, however, it is not necessary explicitly utilised in each application.
- A significant part of engineering practice involves using knowledge of physical principals to solve problems in novel design or via innovation.

Trade engineering

This interpretation omits the trade sector of engineering that sometimes falls under the same umbrella term 'engineering'. In particular, machinists, tool makers and fitter turners are all considered engineers in the wide interpretation of term 'engineering'. The trade engineering sector has extremely low female participation, and also low rates of Māori and Pasifika representation. For the purposes of this research, we are concerned primarily with professional engineering. However, trade engineering requires similar academic strengths and cognitive tendencies to professional engineering. Hence, the outcomes of this study could be tentatively extrapolated to trade engineering.

3.1.2 Interviewees' understanding of engineering

Breadth of knowledge of engineering

In order for teachers to be able to inform their students' career decisions, they must be able to grasp the essence of the careers that they might recommend. Interviewees were asked to list their knowledge of engineering related careers in questions 3.3 to 3.5 (Section 2.2.1). Their responses to these question, or similar questions, were pooled to determine the breadth and precision of the interviewees' understanding of engineering practice.

At universities in New Zealand, civil engineering is the most common form of engineering followed by mechanical engineering, electrical engineering, chemical engineering, computer engineering, and forestry. Natural resources, and structural engineering can be considered subsets of civil engineering. Mechatronics is a recent form of engineering, typically hosted by mechanical and electrical departments, and bioengineering is currently an emerging discipline in New Zealand.

The majority of interviewees had a sparse knowledge of the broadness of disciplines within typical engineering practice. In particular, fourteen interviewees noted, or gave examples of structural engineering as a core engineering discipline. All of whom gave bridges as one such example of structural engineering.

> I think of engineering like building stuff, like structural. I think I have always just think of like structural engineer like being bridges. (F16)

Few interviewees gave sparse examples of engineering type careers that were not related to the structural subset of civil engineering. However, F15 was able to give an example of Chemical engineering which was only mentioned by two interviewees. However, she was very tentative about what else engineering may entail.

> Chemical engineering. I guess there's more physical sorts of engineering like hands on sort of things, maybe inventing something and there's behind the scenes of the research, testing. They have to put what they do into action before it gets developed into actual projects and [the engineer] monitors what's going on currently in the community, monitoring what they've got going on. I don't know how true that is. (F15)

Others had slightly broader interpretations but indicated a struggle to describe engineering beyond a very base level of knowledge: "I'm not 100% sure. I know that building and I think mechanics to come under it. I'm not 100% sure on that." (F9).

Another evident grouping of responses showed that some interviewees were almost unable to give a description of engineering. Four interviewees did not give examples of any specific engineering disciplines. In particular, F17 recognised the breadth of engineering without giving any definite examples.

> I know that there's a lot of different streams and you can go down different pathways (F17)

Some interviewees were able to respond with relatively accurate, if still limited, descriptions of engineering. F8 was able to give examples of both chemical and mechanical engineering, drawing on her family members as examples.

> Well ... my brother is drafting windows. My sister in law is also an engineer. She used to work for a company that produces bread. So I think she sees to it that the machines are all working. So mechanical/chemical. I think she's chemical and that's something to do with the bread. Also the formulation of bread. My brother in law [...] works for the company that produces bags where the milk, powders. And so I think [he ensures] machines are working well and producing enough numbers of bags. So I think it's more of machines (F8)

The interviewees' breadth of knowledge on different disciplines was relatively limited. All New Zealand universities that offer engineering offer multiple different disciplines. The interviewees in this study attend universities that also offer multiple different engineering disciplines and yet the majority of them gave examples of only a narrow subset of a single engineering discipline.

Not a single interviewee addressed any engineering disciplines that are involved in designing and building their technology devices such as their phones, computers and tablets although these devices have become ubiquitous to modern society. The engineering design and build for these devices happens out of sight of the majority of the population. The devices' connection to engineering is lost as people do not experience it themselves and are also not taught about the huge amount of energy and time goes into all of the everyday items they commonly use.

Structural engineering construction on roads, buildings and bridges happens in the open and is common to see which is likely why many interviewees drew on this as a source of knowledge for engineering. They are constantly reminded it is there and progressing. They also have a better grasp on the time and effort that goes into it as they are forced to wait every day in the same road works traffic jam for sometimes weeks on end.

Source of engineering knowledge

The source of the interviewees knowledge on engineering gives an indication of where teaching students are currently learning about engineering. The knowledge of engineering presented by the interviewees often came from family, friends, and acquaintances in the engineering profession. No student teachers reported knowledge of engineering practice received from a New Zealand education provider. However, this cohort may not be considered the target of the STEM recruitment initiatives that are currently in New Zealand schools. Since few students have family or friends in the engineering field, many students will go through their primary and high school education without a sufficient understanding of engineering to make an informed career choice. In order for the New Zealand education system to aid in diversifying engineering cohorts, teachers must have an accurate understanding of engineering practice. While not directly investigated in this research, one may consider that there is likely to be a similar imperative for other careers that lack diversity (nursing, teaching, accounting, building/trades, etc.). To ensure teachers are graduating

with an understanding of different career paths, it should be included in the curriculum.

Eleven of the interviewees discussed people they knew while describing what engineering is. Three of the interviewees mentioned colleagues or peers, eight of the interviewees drew directly on close family and friends as their source of knowledge on engineering. One interviewee very clearly stated when describing an engineer that she was picturing her brother. “Engineer, good at math, good analytical skills problem solver I'm thinking of my brother, he’s an engineer.” (F8). Interviewees also related engineering to their friends who were studying engineering. “My friend studied [engineering] and they’re always busy ...” (F4).

Family and friends often appeared to be the main source of information on engineering, as demonstrated by one interviewee who continuously referred to his father and brother (both engineers) throughout his explanation of what engineering is.

> I remember my father would travel the world and look at the heat boilers or engine in an engineering systems and bring it back and make these things and redesign it. ... So my father actually would work with my brother because my brother's fitter turner may have two to work on the layer to create some of the parts for that. (M5)

The interviewees who personally knew engineers tended to have a broader grasp of what engineering is. Four of the five interviewees who gave examples of multiple different engineering disciplines drew on family or friends as examples.

> it depends on what type of field it is, but basically it's almost like maintenance and repairing in a real nutshell because my friend is an automotive engineer, so he fixes, builds and repairs cars. My dad was technically an engineer but working in... not a factory but he had to fix like the silos and all the big parts of that and that involves a lot of problem solving like OK here's the problem, what do we need to fix it and how do we fix it kind of thing? The structural engineers, they fix anything that need to deal with dams or bridges, or make... so the whole making aspect of it too, they're making, fixing and repairing, maintaining. That probably be how I’d describe it in a short sentence. (F2)

Using family as a source of information on engineering sometimes led interviewees to use what seemed to be a non-engineer as an example of engineering. This implies they were unclear on the definition of engineering.

> I'm kind of picturing my dad for some reason, like, because I think he does a lot of like things like the painting and the cars and stuff and he's very much always covered in oil or overalls because it's cold where he works (F9)

Although this interviewee was able to draw on her father as an example of an engineer, the description of the work he was described as engaged in would not often be classified as engineering. The interviewee's understanding of engineering has been largely influenced by an understanding of a job related to, but outside of the engineering field.

The understanding of engineering that comes from family and friends was one of the best sources the interviewees had. However, this source gives different information to everyone and results in a large variation in understanding. Not everyone has a family member who does engineering and is able to teach them what an engineer does. The unbalanced sources of information left some interviewees with a much higher level of knowledge than others.

Understanding of the culture and practice of engineering careers.

The interviewees' understanding of the culture and practice of engineering has been characterised by their understanding of key aspects of engineering; the importance of problem solving, the technical requirements, the soft skill requirements, and the professional sector.

The wide variety of different engineering roles has led to difficulty in creating a definition of engineering. Section 3.1.1 shows that engineers are concerned with the generation and innovation of products, using technical knowledge and problem solving skills. Two of the four definition providers specifically stated 'problem solving' in their description, one mentioned 'getting things to work' however that is done, and the fourth author believed engineers 'achieve goals'.

Ten of the interviewees mentioned the importance of problem solving in relation to engineering.

> Engineer, good at math, good analytical skills, problem solver (F8)

A larger group, however, did not discuss problem solving. Whether or not this was because they believed you don't need problem solving skills for engineering or they just forgot to mention it is irrelevant. When asked 'what are important ... traits?' and 'what skills do engineers need?', 11 interviewees failed to mention or imply problem solving, even though it is a core value of engineering work. In general, prior to being explicitly asked about the communication tasks engineers need to undertake, most interviewees focused exclusively on technical abilities as the important skills for engineering.

> It's a lot of math, I think that they've got to do a lot of different technical things to figure out, like the dynamics of [inaudible, presumed 'various things'], for example even building a bridge or something, they're going to try to figure out the length, the perimeter and the strength of the wood, the metal and stuff like that, there's a lot of math involved, that's all I'm aware of. (F4)

Engineering often uses physical principles such as mathematics and science to accomplish specific tasks. The definitions in section 3.1.1 found a consensus with every author mentioning either physical principles, mathematics, and/or sciences. Physical principles are the tools used in engineering. However, they are still only one component of engineering practice. A good understanding of physical principles won't guarantee engineering success. The majority of the interviewees in this study recognised the need for a high academic ability and heavily focused on mathematics and sciences as academic requirements for engineering.

> It might be somewhere you'd actually get to use trigonometry or something. I imagine there'd be mathematical and physics knowledge involved. So I would think of it as a science, maths thing looking for relational skills. (FL1)

Mathematics and sciences usually receive an excessive attention as the academic gatekeepers to engineering. However, many other skills are necessary in compliment to technical ones for effective engineering. Some of the interviewees were able to recognise this and commented on the importance of more creativity focused subjects, although, always in conjunction with mathematics and science. One interviewee agreed that the students should also be interested in art, not just maths and science.

> Like academically a high performance and even in interest, because there's a lot more room, just engineering is just a huge umbrella. So it depends where you want to go. So yes, between science, arts and math (F2)

Note that F2 included 'art' in the characteristics required for an engineering. While this is not generally considered within the expected skills profile of a typical engineer, creativity is very often valued in good engineering. In particular, creativity is an important element of novel design engineering. Two of the four authors that provided descriptions of engineering in section 3.1.1 mentioned creativity. However, in determining that the process of 'making something work' by means outside of established methodologies, a third definition implies a creative process. Hence, the 'outside-the-box' thinking and imagination that are valued in art, but not so valued in technical subjects at a pre tertiary level, can become very valuable in engineering practice. Hence, students with a strong aptitude in art and a general competency in mathematics and science should be encouraged to consider engineering as a career.

Some interviewees also recognised the softer skills needed in engineering such as communication. Engineers' social skills have been derided for many generations. The stereotype of the socially inept engineer is pervasive and is a stereotype many of the interviewees turned to when describing/asked to describe an engineer. Engineering in our modern society requires a competent use of many different soft skills in order to achieve success. Most projects now have interdisciplinary components that require engineers to work in cohesive teams to optimise a solution. Projects are completed for clients by engineering

firms with need of clear communication to ensure what is delivered to the client is precisely what they actually desired. Design engineers must communicate with contractors and technicians to optimise their designs while still enabling them to be built efficiently and effectively. Hence, soft skills are vital to engineering. However, these skills are often regarded as significantly less important than academic/technical skills. One interviewee stated very clearly that she thought the need for communication skills in engineering work was very minimal.

> I think it's quite just very minimal. They just communicate like this: "This is the measurement". I think it's more of like that, more of the calculating side and less of the communication. (F8)

There was a large group that did recognise the need for communication skills in engineering work. One interviewee recognised the need for communication to ensure that individual parts of projects come together in the end.

> Yes, I feel like communication would be quite an Important thing because they have their own individual task on a [multi – person] project or need to be understanding the wider picture that's forming while people working on something. (M12)

Another group still fell back on the socially inept stereotype for an engineer even when they had previously recognised the need for social and communication skills. The same interviewee in the previous comment that emphasised an importance on communication skills, when asked to describe an engineer, commented on the engineer's 'bizarre' social skills. "a middle class white dude who might be mildly overweight and has bizarre social skills". (M12)

Communication skills are ubiquitous in modern engineering as most engineers work in large teams with various skillsets. The professional sector of engineering often has additional communication challenges as they need to communicate with clients to try and uncover what the client actually wants from them. This task is typically difficult by due to the average clients' inability to use, or at times understand, technical engineering terminology.

Of the 22 interviewees, 13 stated engineering was practical; with most of these mentioning building and or construction. However, there was some confusion in defining "building" as exemplified by F9: "I'm not 100% sure. I know that building, and I think mechanics to come under it. I'm not 100% sure on that".

There is a paucity of practical tasks within typical engineering practice. Practical engineering tasks include specimen analysis, site visits, research and development experimentation and testing, and prototype assembly. Professional engineering is more design focused and uses more research and development in projects. The majority of the professional engineering industry work mainly out of offices, at computers, in smart office attire. The professional sector of engineering was one that was often disregarded by the interviewees in this study. More often, they turned to descriptions of more practical engineering occupations to help them describe what engineering is. In particular, the understanding of civil engineering tended to be weighted towards the more practical, on site positions. One interviewee automatically thought of the people that build the road when asked about engineering. The road builders are usually construction workers as opposed to the engineers that designed the road.

> Engineering, I automatically just think of people that build the roads and bridges and buildings and how everything is made, how structures are made safe. (F14)

F14 may have been combining design with building. But they did not seem to realise that these tasks are usually completed by people with different occupations. Another interviewee was much more explicit though in describing a cartoon engineer as a construction worker.

> Straightaway that's probably be a guy. I just think of all the workers that are around here though, in [my] University, really in their animated form, which I didn't even know it, right, but that's just what I think of straight away. High (visibility vest), work boats, probably have two of them maybe. (F14)

This interviewee attends a university with many professional engineers in training and yet turns to the image of a construction worker as an engineer. Their understanding of professional engineering is very limited. A lack of understanding of the professional sector was common across nearly all interviewees. One of the only examples that addressed areas of professional engineering that are office based focused on how engineers are not interested in 'hard work' and instead want to sit down while working.

> they don't want to enter trades with they might necessarily need to be like sweating and working really hard physically. They have sort of inquiring minds and want to solve problems they so they pursue a university field where they can sit down an office and do well that way rather than working as an electrician or plumber I guess.

However, this interviewee was not necessarily wrong about the reasons for some people becoming engineers, nor the tendency for professional engineers to work predominantly in an office environment. For some, including an author of this report (Dr Docherty), a significant reason for leaving the trade sector was to reduce the physical strain of trade work. While not typically physically demanding, there are generally significant stress and time demands in professional engineering practice.

Some of the interviewees didn't even recognise the professional sector at all. One interviewee even went as far as to say that engineers learn what they need to know on apprenticeships and that their work is always hands on.

> They know how to put little things, and the things that most people wouldn't know. Like I know they learn practically like they learn on that apprenticeship. And so, like, everything they do is hands on. That's pretty much my knowledge on it. (F9)

The majority of engineers in the professional sector attain their qualifications through a university environment. This interviewee shows a complete lack of knowledge of a significant portion of the engineering industry and most of the design elements of engineering. They won't be able to give students advice on the professional engineering career path if they are not aware it exists.

While some interviewees had a reasonably accurate view of subsets of engineering practice, most interviewees had a very vague understanding, and some were ultimately incorrect. The interviewees demonstrated a limited knowledge of the structural subset of civil engineering but few were able to give examples of engineering disciplines outside of civil engineering. Many interviewees drew on close family and friends to help them explain engineering. Having a close relationship with someone in the engineering industry added to the quality of their understanding of engineering but did not significantly increase the breadth of their knowledge. Also, not everyone will have close family or friends in the industry from whom to learn about engineering. Student teachers should have access to general but accurate sources through which to learn about engineering and engineering practice.

The academic requirements were a large focus for many interviewees. Aptitude for mathematics and sciences was generally accepted as being significantly more important than soft skills. Some interviewees even went as far as to state that communication skills are not important to engineering. To succeed as an engineer, communication skills are vital. Engineering requires a significant amount of teamwork and collaboration which becomes incredibly difficult when communication skills are lacking. Teachers need to understand what attributes help engineers succeed in order to recommend students for engineering who would actually excel. The recognition of the professional sector was almost non-existent with many of the interviewees characterising engineering in terms of practical or 'hands on' tasks. The limited knowledge the interviewees had relates to an inability for teachers to inform students on the vast majority of the engineering industry.

3.2 Interviewees' perceptions of engineers and engineering

The interviewees were asked to describe a 12-year-old who they would consider advising to enter the engineering profession. Later on, they were asked to visualise a cartoonists drawing of an engineer (interview questions 2.4 and 3.7, Section 2.2.1).

Interviewees held strong stereotypical views of engineers and their related tasks. This was most obviously illustrated by M5, who described an engineer as a male, with tools all round him and in brown leather shoes, wearing a hard hat: “not afraid to put in a pair to steel cap boot”. However, M5’s wife was an engineer, whom he later describes as follows: “But my wife is 5’3”, slim, Korean girl and yet she did [engineering].”. Hence, the male engineer stereotype is strongly pervasive, even when the sterotype is contradicted by a close family member. The brother and father of this M5 also engineers and were likely to have reinforced this stereotype during his formative years. He met his wife at a later stage in life when his stereotype of engineers may have already been solidified

Three further themes emerged from the data in this section: 1) tasks and role of engineers and engineering, 2) personal characteristics of engineers and 3) communication skills needed for engineering. Asked to define engineers and identify the technical, communication and social tasks engineers might do interviewees’ responses varied. Three interviewees had either no idea or only vague notions engineers and what they did, exemplified by F6 who said, “I’m not too clear on engineering, sorry”. Design, creativity and interpersonal skills were also noted by number of interviewees as key attributes of potential engineers. M7 noted the need for engineers to consult with experts form other fields: “Getting the right people to come up with a backup solution”. F20 also stated “They design, like they create bridges and designs structures”. F8 noted a significant hurdle for engineers is “the inability to think past to only look at a solution from one side” F2 was able to recognise the need for aesthetic consideration in some engineering applications, “What’s the best design that would work the best and some people’s mind, what would look good too. Because you don’t want it to look hideous but does the job well, so apparently the balance there I think”

Several characteristics and personality traits of engineers were identified by the interviewees when asked to describe a cartoon of an engineer and summarised in Table 4. Overwhelmingly interviewees saw engineers as male

supported by this quote from F10, “Males go towards engineering type degrees and females go towards teaching”.

Almost half the interviewees saw engineers as middle aged and five specifically mentioned that they were of European decent or “white”. However, this was in in response to the ‘draw an engineer’ question, and thus, the interviewees may have been led towards providing a stereotypical view of engineers, that they may not necessarily hold themselves. However, in for a minority of interviewees, their later responses, discussed in section 3.6, imply that ethnic prejudice may have contributed to this response.

F17 had some female friends from the country that were becoming engineers and led to more a more general view of engineers as ‘country type’ girls. F17 said “country girls, always country girls, boarding girls, those are the people.” while F8 said, “a female with no makeup on. Yes, the more sporty type of female not a feminine side”. Such attitudes may cause prejudice against recommending engineering careers to feminine students. Four of the interviewees were embarrassed at their stereotypical view of the engineer cartoon. This embarrassment was exemplified by F3

“Honestly male, which is quite sad because you'd like to think that the image that I had in my young age will necessitate…This is so stereotypical” When asked “why?” she replied “it's really sad because my youngest sister [redacted name], I try and visualize her in a role like that there, I tried and you still go to what you know and it's like ‘zip’ when you asked the question.”

Descriptors Engineers are	Male	Nerdy, Diligent, Intelligent	Casually Dressed	Work Tools & Equipment	Middle Aged	Safety Equipment & clothing	Ethnicity European	Unsocial	Embarrassed about Stereotype
Lecturers N=2	2		2	1		1	1		1
ITE students N=20	18	12	10	10	8	7	5	4	4

Table 4: Summary "Describe a Cartoon of an Engineer"

Over half of the ITE interviewees recognised that their cartoon would appear to be academic, diligent or hard working and four specially stated that the engineers would have limited social skills. F13 went so far to say "... and has bizarre social skills".

When asked about characteristics of engineers most interviewees indicated that they would be academically inclined with 'nerdy' tendencies. F4's comment sums up many interviewees' views of engineers. "Typical engineer; male, glasses, slightly nerdy". Two recognised the methodological nature of engineering. F6 stated "It would be the ones who are passionate about math who like to do things a certain way, who are very good at following steps".

Eight interviewees saw engineers as being middle aged and over half thought it likely that engineers would dress casually, wear safety gear such as hard hats and work boots and be using tools and equipment such as clip boards, pencils, hammers and spanners etc.

Conversations with interviewees about engineer's communication skills revealed a number of interesting points. Ten ITE interviewees recognised the need for engineers to have some communication with a range of stakeholders

such as fellow engineers, architects, builders and clients, again exemplified by F2

> You've really got to have that communication and that teamwork and cooperation side of things because you need to verbally explain what you are doing, or how you think that this works or even it could be someone new coming along in your experience, and you say okay this how we do things, as opposed to writing something and someone reading it, going I guess to get it because half the time if you write something you're still going to need to explain it in time of questions because of that doesn't make any sense or [others will say] 'oh that makes sense now because you have explained it'.

Some of the 10 recognised the need for strong elements within the wider communication skillset. Specifically, F3 recognised the need for oral language skills,

> Good listeners because they need to take the idea of what's going see it and be able to interpret it onto a page.... they're dealing with customers, dealing with a want and to be able to bring that out and also working with others to achieve this, so not only customers but the people that can do it, the builders.

F4 identified the need for communication skills alongside core mathematical and data analysis skills.

> [Engineers have] to record a lot of results and data and mathematical stuff, and there have to be a lot of communication through for one another, positive communication process. Also they have to know how to communicate verbally, a lot I know that goes there, there's a lot talking and writing down,

F6 identified the need for written skills and conflict management skills.

> they would have to have quite a strong written, because sometimes they would need to write like essays and paragraph, good like in spelling, punctuation and grammar but then you'd need to have good communication skills, probably dealing with conflict and things like that maybe problem solving skills is probably strong in that field.

Three of the interviewees thought that the need for communication skills was minimal. F8 stated “I think it's quite just very minimal. They just communicate like this. This is the measurement. I think it's more of like that, more of the calculating side and less of the communication.” And F9 thought that communication skill requirements for engineering would be of a lower level than the technical elements. However, their examples perhaps imply they are referring to a car mechanic rather than a professional engineer. “Like mechanics and they would still have to deal with people like insurance companies, maybe police reports, but not so high level thinking”.

F15 initially was unsure, but ultimately gave the opinion that engineering practice did not really require social or communication skills. “I don't really know what social, how social engineers are if they work individually or if they work in a group. In my opinion, engineers sort of had their own individual role within the company so I don't know if they have a lot.” Having identified how the interviewees’ perceived engineers and engineering they described primary aged children who might become engineers.

Interviewees’ personal experiences heavily influenced notions of engineering and engineers and were the most confident when asked to define an engineer. Some who had family or friends who were engineers generalised the strengths and weakness of their examples to all engineers. F8 exemplifies this in the extract below and F2 in previous extracts.

> Engineer[s], good at math, good analytical skills problem solver I'm thinking of my brother, he’s an engineer. So he’s not so much of a social person but he can solve those [problems]. He can draft those things that they need for engineering. I think organized also because there's steps into solving their problems.

3.3 Characteristics of children who might become engineers

This section outlines interviewees’ perceptions of school children who are likely to become engineers. The key themes that emerged from the data can be

broadly categorised into three themes: Academic, Creative & Social. Each is discussed the sections below.

3.3.1 Academic

When asked about the characteristics of children whom they thought might become engineers there were a number of predictable responses including those from the lecturers and some contrasting responses from the ITE students. Predictable responses included the need for academic skills of maths and science, 13 and 10 of the 22 interviewees stated that children needed academic ability in maths and science, respectively. Interviewees also recognised that students who were diligent, precise, open-minded and intrinsically motived and passionate about their learning were likely to become Engineers. F4 explains,

> High in math, if I saw a kid who was not just good at it but excited by it and like knew what they were doing and wanted to learn more about it, definitely recommend engineering, a student who is very.... has a certain way of doing things and also being very open minded and I know that you have to be open minded for a lot of things.

F17 identified diligence as a useful characteristic for potential engineers. “Good at maths, good at sciences and quite passionate, not a slow thinker but I mean someone who thinks things through, got to be hardworking”. The following quote from lecture FL22 sums up the majority of views in relation to broad academic achievement and potential engineers.

> Not that I know an awful lot about engineering but I know some years ago, there was a little boy who was in my new entrant class and I always referred to him as ‘my little engineer’ because he was very strong with his math, he was very strong with his English, reading and writing I suppose and he was a talent across all subject that I’d thought you've got such a great line-up of talents. I imagined that he’d be a very good engineer. FL22 Lecturer

On the other hand, F6 and F9 stated that potential engineers were those children who do not achieve academically. F6 also held an explicit gender bias: “They’re

like mainly males and they didn't really [achieve academic] standards" and F9 noted creative rather than technical academic abilities.

> I would say very hands on, building. Like those kind of kids, you can see from even like five, six [years] because they're the ones that get into the Lego and they're always creating. If you tell them to stop, they get annoyed. Then they don't really, and I am generalizing, they don't really care about their academics and methods. This is what they are building -the structures.

3.3.2 Creative

Ten interviewees indicated children needed to be makers, to be creative, and problem solvers. This is juxtaposed to the views of engineers as adults, wherein creativity was seldom mentioned. Each of these is exemplified in the following quotes. F10 states the importance of making,

> once again when I was back in school, they like to do activities where they're physically building something or they're planning out a process which they have to go through to get to a certain stage, I think those kind of kids that are really kind of hyperactive and enjoy putting things together, would be the type of people that would become engineers.

F15 emphasises creativity "I guess they'd be quite inventive and be creating things and trying to find a solution". F4 thought that "a student who [...] has a certain way of doing things and also being very open minded" would be a potential engineer, and F11 the need for problem solving, "They would be interested in math and science, and like problem solving."

F19 recognised a quite accurate combination is required for successful engineering practice. They indicated the ability to combine technical ability, creativity and critical thinking is important for an engineer. "Technically creative. So someone who's good at building but also has that mathematical mind and can marry them up. Yeah. So just the balance between those two things".

3.3.3 Social

Two contrasting ideas make up this theme. Six students indicated that potential engineers would be students who were able to work collaboratively and have good relationships with those around them. These ideas are exemplified by F2, who said “I think [they would need] cooperation because in engineering there’s a lot of group [work]and a lot of team based...., and you know you have to work with a lot of all people” and M12 who stated: “a good engineer has again a good relationships and being able to understand your clients brief”.

F11 suggested that potential engineers do not have to be as strong in social skills as other professions that require emotionally charged communication tasks to be undertaken:

> They don't have to be as personable as a teacher or a doctor would have to be. They have to be very persistent, I guess because they're drawn to problems. So, they have to persist at anything.

Others felt that quiet and reserved children were best suited for engineering careers: “He is not like a people’s person, maybe a bit more reserved or quiet’, and F4 “Maybe even quiet, like a quiet student, who is lively as well.

3.4 Influences in Career Choice

In the early stages of the interview, interviewees were asked who influenced them to train to become teachers. Around the middle of the interview, they were asked who influences the in career selection for children aged 11-13. After their response, they were asked specifically what the teachers role in influencing students was. Some responses reflected their own experiences and some on their beliefs rather than actual experiences.

3.4.1 Research questions

1. Who influenced the interviewees, and who do they think influences children aged 11-13?

2. What was the level of agreement between their own formative influence and the influences they attribute to others?

While the whole transcripts were considered, responses to Questions 1.4 'Consider the person or people in your life who was/were most influential in you deciding to be a teacher' and 2.7 'Who do you think has the most influence of children's aged 11-13 career choice' were carefully analysed. In contrast, the responses to the question 2.8 'what role do you think teachers play in that (the influence on children aged 11-13 career selection)' (section 2.2.1) were ignored while generating table 5. Since all interviewees were specifically asked to talk about what feel the teacher's role is, the question ultimately led the interviewees to accept teachers have an influence. Hence, responses to this question could not enable valid summaries of the interviewees impressions.

3.4.2 Outcomes

Four broad themes emerged in the data. These were 'Teachers', 'Parents' which we defined to include whanau, guardians and very close family members, 'Friends/Peers' and 'Media' which was defined to include social media. Interviewees typically offered a series of influences, but declared one as the major influence. A few interviewees declared two similarly weighted influences. Table 5 shows the responses from the 20 student interviewees and 2 lecturer interviewees.

When considering who influenced the interviewees, parents were most influential, followed by teachers and friends and peers, respectively. Media did not influence any of the interviewees to be a teacher, which is interesting as there are frequent efforts to attract people into the teaching profession via television commercials in New Zealand.

Parent influences on interviewees

There were 14 interviewees that noted parent or close family members that influenced them to be teachers. In three of these cases, a parent was a teacher, and in one, a grandmother was a teacher. Due to the nature of the relationship

between the interviewee and their parents, one may expect that the influence passed onto the interviewee was predominantly coming from the parent acting in the role of a parent, and not in the role of a teacher. However, the cases were noted in the table to allow independent judgement. A typical response that shows the influence of a parent on the teaching is given by F4 and M5:

> It's my mum. She always wanted to be a kindergarten teacher and she said to that I'd be really good teacher and that kind of stuck with me and I've got to realize that I do love kids and stacked with that. (F4)

> No I can't say that I had any experience through my schooling where this person says I think you've got some good qualities to be a teacher. So there wasn't a single teacher figure that way. I think the way our family dynamics kind of was we were, there was all always elements of lessons going on. (M5)

Whereas F19 had a father that both offered direct encouragement into the teaching profession and was incredibly influential as a parent that role modelled a very positive teaching practice and outcomes.

> Yeah. So my dad, with that advice, [to become a teacher] he was just brilliant. I still bump into people that I went to school with who just always comment on my father and just the influence he's had on them. If I can be a little bit like him that'd be great.

Interviewee	Teachers		Parents		Friends/Peers		Media	
	Students	Self	Students	Self	Students	Self	Students	Self
F1	✓	✓✓	✓✓					
F2	✓	✓✓	✓✓	✓✓				
F3	✓		✓✓	✓✓	✓			
F4	✓✓		✓	✓✓				
M5	✓		✓	✓✓	✓✓			
F6	✓✓		✓	✓✓				
M7	✓✓		✓			✓✓		
F8	✓✓	✓✓	✓✓		✓✓			
F9*			✓✓		✓✓			
F10	✓✓	✓✓	✓	✓				
F11		✓✓	✓✓	✓✓	✓✓		✓✓	
M12	✓✓		✓	✓✓				
F13	✓	✓✓	✓✓					
F14	✓	✓✓	✓		✓✓		✓✓	
F15	✓		✓✓	✓✓†				
F16			✓✓	✓✓†				
F17	✓✓	✓✓	✓✓		✓			
F18**	✓		✓✓	✓✓				
F19	✓		✓✓	✓✓†				
F20	✓✓			✓✓ ††				
FL21		✓			✓		✓✓	
FL22			✓✓	✓✓				
Totals	✓✓ 8 ✓ 9 - 5	✓✓ 9 ✓ 0 - 13	✓✓ 13 ✓ 7 - 2	✓✓ 13 ✓ 1 - 8	✓✓ 5 ✓ 3 - 14	✓✓ 1 ✓ 0 - 21	✓✓ 3 ✓ 0 - 19	✓✓ 0 ✓ 0 - 22

Table 5. Summary of responses to questions regarding who influenced the interviewees career decisions and who they think influences children in the critical age bracket of 11-13. A double tick ✓✓ represents the major influence, and a single tick ✓ indicated a secondary influence. (Notes: *F9 could name no particular individual's influence on their choice. F9 trained to become a teacher after being offered a job teaching a certain skill (undisclosed to maintain anonymity) and enjoyed it. They applied for a different job, but was offered and accepted the role teaching; **A hobby (undisclosed to maintain anonymity) teacher also inspired F18 in a major way;† denote parents that were also teachers – listed as parents due to the dominant relationships mechanics (†† Grandmother was a teacher).

In contrast, F8 did not seem to receive impactful encouragement into teaching from her immediate family.

> I think it's [the influence to become a teacher] more from my teachers. Because in our family, I don't remember anybody going into teaching. Most of my family are into business. So I think I saw it in my teachers as I was growing up.

Teachers influence

Teachers were also often noted as major influences on the interviewees decisions to become teachers. Seventeen of 20 student interviewees noted that teachers were important influences on the career decisions of students in the critical 11-13 age group. However, neither lecturer noted the role of teachers as important influencers. In particular, F1 had a strong teacher role model who influenced her decision to become a teacher:

> But I had one really influential teacher who solidified my desire and my passion and my want to teach. That was a male teacher, my year 7 teacher, his name was Mr. [redacted] and he was just awesome. I just thought he did so many cool things that engaged the class and it made me see teaching as a profession, as something that would be fun. He always seemed to be having a good time, it would be rewarding.

And F14 noted the role model aspect of the influence:

> [major influences on my choice were] probably my teachers at primary school. ...I think because when you're there they are quite eager to school every day. You sometimes see them all the appearance so, they become that role model for you

F10 noted that parents were a major influence on the career confidence of students aged from 11 to 13 years, but also noted that teachers held more influence as they governed the delivery of the curriculum.

> I think parents are a big factor and family members but I think the overall main factor at that age would definitely be the teachers, based on what they teach, pushes them [students] towards more learning in the classroom and sort of inspiring them to choose a different path. If they enjoy science you know they'll go towards that direction.

The cohort used in this study were all intending to become teachers (or currently lecturing incumbent teachers). Thus one may expect that they were more likely to respect and listen to their teachers, as well as be more influenced by the example set in the classroom, rather than the specific encouragement. Hence, the results of this study should not be interpreted to represent the career influences beyond this cohort, for such a conclusion, concerns arising from selection bias would invalidate the results. Conversely, this subsection of the wider study specifically aimed to determine the who influenced the career choices of student teachers, who do they think influences children aged 11-13 and how consistent are their beliefs with their experiences. To answer these questions, the cohort was fully appropriate. Nonetheless, it was difficult to confidently isolate the influence that was generated via example and the influence generated by direct or indirect verbal encouragement. For example, F19 had a father who was both a direct encourager of the choice to become a teacher, and also a very positive role model (Quote on previous page). F4 implied that the influence teachers generate on the career confidence in children aged 11-13 may be via example, and that children may become confident of the role during their time as a student. For many, teaching is the first profession they begin to understand. This example via daily representation in the classroom would be very difficult to repeat for other careers. However, it concurs with research that shows the benefit of positive representation via exposure to role models during key stages of career aspiration formation, particularly for females in the STEM profession.

> I think teachers will probably be the most influential and in the fact that they see them the most often and they get the taste of careers and profession before they starting teaching.

Peers and Social Media

Perhaps unexpectedly, peers and social media were not consistently noted as influences for the interview participants, nor were they often noted as influences for children. Peers were noted as an influence on the interviewees one time and eight times as an influence on children. Media was not noted as an

influence on the interviewees choices and was noted as an influence on children three times. For example, F14 suggested social media and peers as most influential, followed by parents and teachers.

> Interviewer: Could you please rank those responses?
>
> F14: Yeah, probably social media and peers would be first equal, followed by significant others (partners), your parents and teachers.

One of the lecturers (FL21) emphatically noted media as the key contributor to student career decisions with peers also contributing:

> 11 to 13 year olds think a lot about YouTube and video games and social media and fashion and music, which worries me a great deal for a range of reasons. ... Because teachers aren't cool, parents aren't cool, peers are cool in popular media

However, one must be cognizant that this interviewee may not have fully considered the question, as most 11-13 year olds do not tend to have significant relationships. However, the researchers may not fully understand current dynamics in that age group.

Consistency of response

There were generally strong associations between the influences that the interviewees had on their career choice and the who they felt would influence children in the key age bracket. Perhaps most importantly, almost all student teachers who were influenced by teachers recognised the importance of teachers in the role of career selection (7/8). Only F11 was a confounder. However, two students noted teachers as a minor influence when they were influenced in a major way by certain teachers. Neither lecturer independently noted the influence that teachers have on career selection in that age group, while one was herself influenced in a minor way by a teacher.

Among those who were influenced toward the teaching profession by their parents, only F20 failed to note parents as an influence on career decisions (1/14). However, there were 4/14 cases wherein the student teachers' parents were a

major influence to them, but they only noted parents as a minor influence on children. The one student teacher (M7) influenced to go into teaching by his peers failed to recognise the influence peers can have on career selection. However, this interviewee may have recognised that his situation was unique.

3.4.3 Summarizing remarks

The interviewees' responses regarding their beliefs on the influences on the career choices of children were typically informed and consistent with their own major influences. This is despite the questions appearing in quite different stages of the interview. This consistency implies that a level of successful introspection had been undertaken by the interview participants. It also shows that the interviewees were capable of projecting this introspection onto the children they will ultimately teach. Furthermore, consistency in responses over the duration of a scientific interview can be used to validate the ability of the interview approach and the trustworthiness of the interviewee responses.

The influence that parents had on the interviewees to enter the teaching profession generally fell into two categories: influence by example and influence by verbal encouragement and empowerment. Most respondents were influenced specifically to become teachers by the verbal encouragement of their parents. Nine respondents had parents that provided major, and one that provided minor, influence to become a teacher despite none of their parents working as teachers.

Four out of 22 interviewees had parents or grandparents who provided a positive and encouraging example as successful teachers. The interviewees that mentioned parent-teachers as a major influence were all attracted to the example set by their parents and presumably hope to emulate their parents' success. No interviewees declared intention to go into teaching simply because it was appropriate to follow their parents career, despite this known tendency.

Importantly, almost all student interviewees (17/20) noted that teachers have a major (8) or minor (9) influence on their students' career choices. Only 3 student

teachers failed to note teachers as an influence. It is positive that the student teachers recognised that they will ultimately have influence on the career choices of children. This implies that they will at very least, be cognitive of their potential to influence children while they are in practice. However, it must be noted that none of the student teachers made any statements that explicitly recognised that they would have that level of influence on career selection for children.

Neither of the lecturers interviewed noted that teachers would have a significant influence on their students' career choices. This may have been due to the lack of influence from teachers on their own career decisions. However, there were 10 students that noted the influence of teachers on children's career choice while having no such declared influence on their own choice.

There is very clear evidence that teachers have an influence on the career choice of students. Hence, it was good to see that most student teachers implicitly recognised their role in preparing students for career choices as well as careers. We recommend that this coverage is increased to ensure that *all* student teachers (and their lecturers) are acutely aware of the significant influence that they can have on their student's career decisions. This is especially important when upwards mobility of students is desired.

3.5 Perceptions of reasons for low female representation in engineering

Interviewees were asked to comment on the reasons they believe there is low representation of females in engineering. None of the interviewees questioned this statement which, as shown by the data is further supported by their own observations.

There were three main categories under which interviewees' comments could be grouped with regards to what stops females from following engineering

careers: Expectations from society and family, the nature of the engineering profession and limited exposure to female role models.

3.5.1 Expectations from society and family

Thirteen out of the twenty-two interviewees explained that one of the main reasons that prevents females from entering the engineering profession is the expectations that society has of women. These expectations are present in a human's life from a very young age through their family and wider environment, they affect their future choices and require additional strength to go against.

> Sometimes expectations of others can actually change how you feel and it can start at a very young age like if you're doing something to do with maybe building and you're a girl. [...] Sometimes you are going against the expectations that have been set for you (F3)

These expectations are often set inadvertently by the child's own environment. Some interviewees commented that this happens for example when families encourage or discourage certain activities based on the child's gender. For instance, girls are more likely to be discouraged from playing with tools and building blocks or playing in the sand pit. One of the interviewees who was a lecturer in teacher education further explained that she believed girls are less likely to be encouraged to engage in hands on activities that help develop technical skills. "Girls are perhaps already at a disadvantage because some of the boys will be very familiar with engineering types hands on activities, but the girls maybe not" (FL22). The lack of such experiences may affect a girl's own perception of her own abilities and skills associated with the engineering profession. However, such practical skills are used in a very limited capacity in a professional environment, and those that do not have experience or interest in hands on activities should not be discouraged from considering engineering careers.

One of the male interviewees reflected on the family's role in encouraging all types of useful activities for boys and girls while at the same time respecting and supporting the child's own choices and interests. Thinking of his 2-year-old

son who is interested in toys with wheels and his 5-year-old daughter who is interested in dolls, he commented that the children developed their interests with no influence from their parents. However, he noted that in parenting there is always an element of different expectations with certain activities, as in a parent's mind it is not acceptable for girls to play with toys that will get their hands dirty.

Another way that interviewees identified that societal/family expectations affect girls' career choices is directly through parents' and other adults' perceptions of what engineering is about and what an engineer does. Such perceptions exist in the child's family, school and social environment and further shape children's own views of where they see themselves in the future and what career choice will be more suitable for them.

> I think it's because girls are groomed. I think society [says] 'you don't go into that. That's the man's job. (F8)

As one of the interviewees commented, schools play an important role in shaping children's understanding of what engineering is, since families are not always conveying the right messages due to their own limited experience with engineering.

> I don't think they [kids] know what an engineer actually is to be fair. They hear it at home from parents talking about, depending on what their parents do [or] getting an engineer to come and fix something. So it has to come from school. (F19)

One of the female interviewees commented that engineering is often seen as a profession that requires high intellectual ability and dedication that women often lack, due to the expectation that they will dedicate themselves to their family:

> There's a stereotype around men [that they] are perhaps more suited for these sort of intellectual intelligent jobs and perhaps a woman is more suited for focusing on their family. [...] There's a stereotype that men are, I don't know, more like tough, like I said before, hard working.

> Women are perhaps perceived as finding it easier to quit maybe, they don't get the qualification. (F1)

This is a false, prejudiced, and highly deleterious view that if printed forward into practice in the classroom will contribute to the exacerbation of the current gender bias in engineering cohorts. Views such as this should be combated systematically by society in general and the teacher education curriculum specifically.

Finally, some interviewees identified STEM subjects as a pathway to further studies in engineering but commented that there is often an expectation from schools and families that girls are not interested in STEM subjects. A small number of interviewees held that opinion themselves. Interviewees commented that family and school play a very important role in encouraging girls to take STEM subjects in school from a young age.

> [Schools and families] they're trying to provide it [STEM] from a younger age, saying this is a cool thing that you can do, to try and get them interested earlier so that they can do it later on in high school and make sure they do the sciences so that they can go to engineering. (F2)

One of the interviewees commented that both of his children are expected to perform well in STEM subjects, as these are perceived as very important subjects in their family. Another interviewee shared her experience from her own family to highlight the importance of encouraging all kids to follow their interests with no stereotypical biases from the family. The same interviewee further commented on how girls' involvement in STEM subjects has changed over the last few years, based on her experience as a student, mother of a teenage girl and educator:

> She has taken off the science, absolutely loves it. I don't know where that came from, it wasn't necessarily for me. But I know that from me she got that ‘you can do anything you want to do’ and there’s no gender stereotype. [...] I think the STEM subject is now becoming more palatable to girls and the more they are getting into it, it flows down to the next level and the next level after that. Hopefully it'll get to the stage that there's no difference. (F13)

3.5.2 Limited exposure to female role models

Acknowledging the importance of role models in shaping children's perceptions, eleven out of the twenty-one interviewees suggested that the low female representation in engineering is both a result and cause of less females in engineering. One of the interviewees reflected on her own experience growing up and getting exposure to various professions in her social and family environment. The lack of female representation in certain professions was evident. This affected her perception of professions and further encouraged the labelling of certain jobs as male and female.

> Even from like 2 years old, they [kids] are seeing like dads and uncles and they go to the mechanics and the mechanics are males. They'd probably just always associated it with males. I can't think of a time I've actually seen a female did my car or seen a female building or something like that. Even boaters like I can't, I don't actually think I've ever seen a female do it. So growing up that didn't come to my mind. I never once thought, oh, I'm going to be a mechanic, I'm going to be an engineer, I'm going to be a builder because those are male jobs. (F9)

Many of these interviewees also shared that a similar phenomenon occurs in the teaching profession, as the lack of male representation results in less boys showing interest in becoming teachers. "[Engineering is] a very male dominated [field] and that's kind of seen as a male job, just like teaching is seen to be for females because of the nurturing side." (F4)

Some interviewees commented that even if females choose to pursue their interests in male dominated subjects or professions, their sense of belonging is challenged if they feel as a minority. One of the interviewees felt uncomfortable as a student in a class where she was the only female student, and was concerned how females in engineering would feel entering into the engineering sector. "Well at the time when I did this (project management paper) for instance, I was the only girl in the class and it was very intimidating" (F3)

Interviewees commented that females that are interested in a male dominated field like engineering need to be overly confident, as there are additional

challenges for them. One of these challenges is the lack of enough opportunities to establish a network with other female students, which explains why there is lower female representation in this field.

> It's probably also the confidence as a female to push yourself to take the steps and go towards engineering when it's male oriented, I think that's probably why there are not as many as possible. (F10)

> There's also (a challenge) if women can't see themselves doing it and they don't have a peer network who were doing it with them. Then it's easier to think of yourself and envision yourself doing something else. (FL21)

The importance of role models that promote the presence of females in engineering and challenge stereotypical views that engineering is for men was identified by interviewees. As one of the male interviewees mentioned it is important to have these conversations with young girls so that they are able to see themselves as engineers regardless of the low female representation.

> I think that's a big problem with young girls wanting to get involved in engineering they don't have those female role models that have gone down the engineering path to actually have those conversations with them, you know, talk about their experiences and maybe the things they are concerned about with interest, and just breaking down those barriers. (M12)

One of the interviewees noted that presenting female engineering role models as heroes may have a counterproductive effect on increased female participation in engineering. In particular, if female role models are presented as heroic, those considering engineering may consider the engineering profession to be much more bigoted and hostile against females that it actually is. It may also cause some introverted females to avoid engineering as they do not feel comfortable with being an anomaly.

> It's only really in recent years that we've started to see some of these occupations represented by woman. And even there, they are still often seen as anomaly, someone who is particularly heroic because they're unusual. It's not yet statistically normal for women to be

> engineers. [...] Heroic in that it is unusual and it's not something that Carrie from down the road does. (FL21)

This does not mean that the presentation of female role models should be avoided, rather that such a presentation should be very carefully designed to avoid accidentally portraying female engineers as abnormal, or engaging in a unique struggle. Furthermore, such a presentation puts an unfair burden on the role models. One of the interviewees explained to become a role model is a 'heroic' action, something that requires higher levels of confidence and perseverance.

> To be a female in the industry, I feel like it'd have to be able to hold yourself, hold your ground and stick up for yourself, and maybe if you don't hit those characteristics or you're a bit more shy and reserved, maybe you just wouldn't push that boundary. (F14)

Another interviewee further talked about the influence of female role models by sharing her daughter's experience in school where she was inspired by her female science teacher. She compared her daughter's experience with her own when she used to be a high school student.

> She had the fortune of having a wonderful teacher in college who inspired her who was a female. I think that made a difference having a female in that role as well rather than just the stuffy old male that I was brought up with. (F13)

3.5.3 Nature of engineering

Four of the twenty-two interviewees attributed the limited number of females in engineering to the nature of the profession. One of these interviewees who was a lecturer in teacher education shared that it is not easy for females to see themselves as engineers, as engineering values male ways of thinking. She associated female ways of thinking with care and nurturing. The interviewee did not further explain whether engineering values male ways of thinking because of the nature of engineering practice, or whether the historical bias to male interviewees led to the stereotype of engineering as a masculine profession.

> It's about the way the systems work and it could be that these systems in some occupations are more masculine and more directed toward valuing male ways of thinking than knowing and loving and all the practical things around family and so forth. (FL21)

The remaining three interviewees held the opinion that engineering is a profession that is not people oriented and is focussed on numbers and singular correct answers, which tends to interest females slightly less. In contrast, the interviewees claimed that females are more likely to be interested in professions that value communication and make use of the caring and nurturing side of people.

> Is it (the reason there is low female representation in engineering) why girls tend to not relate into STEM subjects? I don't know, maybe math is more right and wrong and maybe girls tend to like more literacy time of writing, expressing their feelings, etc. Rather than just being right or wrong based on a number. (F14)

One of the interviewees talked about her own experience as a student who was considering engineering as a possible career path for herself. She explained that the reason she decided teaching over engineering is because she believed that engineering is an office job that does not involve a lot of interaction with people.

> I but I was actually considering engineering before I decided on teaching, and for me the reason I didn't choose engineering is because it just seems like this office [job], you sit in front of a computer and not with a lot of people [...] So teaching appealed to me a little bit more because it has more people, more interaction. It seems like a warmer environment to be in. (F11)

3.6 Perceptions of reasons for low Māori and Pasifika representation in engineering

Interviewees were asked to comment on their view of why there is low Māori and Pasifika representation in engineering. There were five themes that were identified from interviewees' responses: Expectations from society and schools (n=9), family support (n=9), socio-economic factors (n=6), academic factors (n=6) and lack of exposure to role models (n=6). The factors discussed in each theme

are not independent from each other and there is often overlap, as they were discussed by most of the interviewees (thirteen out of the twenty-two) as components of a whole system that affect representation of Māori and Pasifika in engineering.

3.6.1 Expectations from school and society

One of the two strong themes that emerged from the qualitative data analysis was expectations from school and society affecting Māori and Pasifika student numbers in engineering. This was discussed by nine out of the twenty-one interviewees. Interviewees shared that there are stereotypes around what engineering involves, what professions are more "suitable" for Māori and Pasifika students and what subjects Māori and Pasifika students are more likely to succeed in. Engineering is often perceived as a career that requires strong academic focus. Unfortunately, two interviewees felt that Māori and Pasifika students are often academically challenged and are expected to follow careers in sport or trades. One went so far as to imply reduced cognitive ability that was linked to the genetics of Māori and Pasifika:

> I feel like it's because that type of line of work is kind of seen to be for certain types of people and you have to have a certain way of doing things and brain for it. I'm actually not sure why that is. (F4)

> I know that if you're a Māori or Pasifika, sports are your thing, but the academic side of it (learning) is not as strong as that (F2)

Unfortunately, due to ethical constraints, the views of F4 could not be challenged, and they are likely to be in a teaching role at the time of writing.

Teacher expectations were commented on by four interviewees who stated that they believed that teachers often have lower expectations of Māori and Pasifika students. and that these views tend to be influenced by stereotypical attitudes regarding these students' academic ability. If teachers don't expect these students to succeed, then are less likely to believe that careers outside of the stereotype are for them. FL21 stated:

> There's still a lot of institutionalized racism and deficit theorizing in education. So if the teachers don't consider the Māori or Pasifika student is capable and the expectations are lower, then that student's going to buy into that too and isn't necessarily going to achieve as well.

F8 also noted second-hand observations of explicit prejudice shown against Māori and Pasifika from teaching staff.

> I've heard from the secondary classmates that they were saying sometimes teachers don't also encourage them. It's like if they're not good at all, you just go to this part, don't bother, choose another path. Not that they don't give any effort into teaching them but I think it's the support. Maybe there is a stigma. (F8)

Five interviewees also stated that they believed that Māori and Pasifika culture stressed the importance of family and community therefore students were expected to pursue careers in family or community oriented areas. This has the potential to affect the level of support they provide their children to follow careers such as engineering. One of the interviewees, through her experience in a Pacific island school, indicated that engineering careers were seen more as careers that focus on personal gain noting that the focus on community and family was very strong in the Pacific islands. She further explained that students were encouraged by their family, school and society to follow careers where contribution to their community is more evident.

> So I did my placement in about October, so I got quite a bit of an island experience, like the real island experience, not the glamour, and what I did was very hands on, very family [focused]. It's for people. So they get told that they do careers for the community, not for personal gain. (F9).

The focus on family and community is further discussed in the family support theme.

3.6.2 Family support

Nine out of the twenty-two interviewees mentioned limited family support to follow careers like engineering as being one of the factors that affect Māori and

Pasifika student numbers in engineering. Two interviewees attributed limited family support to low interest in education in general from Māori and Pasifika families.

> To be honest, perhaps it stems from childhood. I don't know this for a fact, but it's seems as though perhaps families aren't as excitable or engaged in learning at home. Perhaps that child doesn't have the motivation to pursue those sort of intellectual fields. (F1)

Most of the interviewees who talked about limited support from families, attributed this to a range of factors, such as family members' limited academic ability to support their children with STEM subjects, their lack of time to extend student learning, limited support network with other families who are interested in STEM subjects, unfamiliarity with the New Zealand education system (for first generation immigrants) and focus on growth as a community rather than as an individual.

One interviewee argued that low interest in education is something that first generations of immigrants are likely to have as they were brought up in a different education system. The interviewee further argued that as families become more familiar with the New Zealand education system they understand it better and their interest in education is likely to increase.

> I think it has a lot to do with the cultural background, I think parents from that culture they don't take school as seriously as a family who was brought up here. But people who were brought up here they know how it goes, like my parents. But now that I am like the 2nd generation here or 5th generation here I think it's important because I live in it. (F17)

Another interviewee commented that learning in school should be extended at home, but this is not always something that Māori and Pasifika parents are able to provide, as they often have to work longer hours and they themselves did not have the opportunity to engage in education due to socio-economic constraints (this theme is further discussed later). He suggested that holiday programmes focusing on STEM subjects and targeting the whole family, rather than just the

children are likely to attract parents' interest who can then inspire this interest to their children as well.

> If I can get mums and dads to bring the children down and give them sheets of paper and say walk around the lake and take photos of different leaves and try to orienteer, find these things and do the tags. If the community can get involved in that then the perception by the child (is) like... it's okay. (M5)

Another interviewee noted the combination of limited connections that first generations of immigrants have, financial boundaries and religion and its relationship with science that affect these families. As a result, they are not able to support children to follow careers such as engineering, which requires focus on subjects like maths and science.

> If you're middle class, you can afford to... you know... your son my daughter and [...] you can find the children to elevate them into that position of wanting to do a STEM subjects. [...] financial boundaries might be affecting those cultural groups, then it could be possibly there are quite spiritual groups Like Christian Catholic. Science and religion are often like clashing [and there are creating] kind of uncertainties around the world, so maybe Mum and Dad are holding you back there. (M12)

3.6.3 Socio-economic factors

Six interviewees mentioned socio-economic factors limiting Māori and Pasifika student options and affecting representation in engineering. Such limitations were identified in the children's school, family or wider community.

Two of the interviewees talked about socio-economic status as the single factor that affects Māori and Pasifika student options when it comes to their career plans. One of these interviewees argued that Māori and Pasifika families often live in areas where schools are classified as lower decile schools. According to this interviewee, the quality of educational opportunities that children experience in these schools is not comparable to the opportunities that children are provided in higher decile schools.

> So the quality and the opportunities that are provided for them, are not as much as someone who is able to pay or in a different area and I think it makes a huge [difference] of what's given, even though it's a school setting, that you get the same maybe... it's not the case, the same opportunities aren't given. (F3)

The other interviewee explained that tertiary study often requires students to get study loans, which is something that may be challenging for these students. The interviewee did not anticipate any other limitations if there are no financial constraints:

> F18: It is very financially hard to get a loan and will need to get a lot of money.
>
> Interviewer: What about even people who are Māori or Pasifika from high socio-economic (backgrounds), do you think that they're likely to be influenced this way?
>
> F18: Not that I can think of, if they have got a technological mind.

Other interviewees talked about socio-economic factors and their interaction with other limitations, such as family support, society and school expectations, academic ability, and lack of role models. One interviewee, for example, who is also a lecturer talked about educational opportunities, combined with career perceptions of these kids and their families, especially in terms of what professions they perceive as appropriate for them. This relates to the previous themes of family support and expectations: "it depends on [...], the availability of opportunities, the attitude towards careers." (FL22)

Another interviewee explained how socio-economic factors affect the level of learning support and encouragement that parents are able to provide to their children which in turn affects children's academic achievement:

> I think the ceiling has been considerably lower for more reasons than one because parents have been in roles that have been low skilled or unskilled work [...] How do they (kids) get any opportunity for learning about that (e.g. science) when dad goes to work, is picked up on the bus at six in the morning, goes and does a shift work, comes home? He may be a very loving and supportive dad but where is that, where's

> that tinkering in the weekend? Where's that honey let's look at this and I wonder how that works? (M5)

3.6.4 Academic factors

Another theme that was identified with regards to low numbers of Māori and Pasifika in engineering is relating to academic challenges that these students experience in schools, according to six out of the twenty-two interviewees.

Three interviewees mentioned language as one of the barriers to academic success, as for students who speak English as a second language, learning in schools that teach only in English might be more challenging: "I feel like if it was a second language thing it might be a little tricky for them to be able to understand" (F4)

In addition to language, as mentioned in the family support theme, the New Zealand educational system and parents' limited ability to provide support was mentioned as another factor that affects students' academic achievement. Some interviewees mentioned that schools tend to focus remedial efforts more on Māori and Pasifika students' literacy and numeracy and noted that this may affect these students' confidence to consider more technical academic careers.

> I've noticed in my placements and even in high school, just being on the board, Māori and Pasifika are targeted for... targeted for their literacy and math. Targeted means we really need to make sure we watch them and help them because they're a little bit behind where they should be [...] so I suppose being you know this target and not having high literacy at a young age can probably affect them. (F2)

Another student argued that students' academic achievement before they transit to high school can really affect their confidence and goal setting for the future. If the student has experienced failures and has not been provided with opportunities to succeed in a range of subjects, then their level of confidence will be lower. Of course' the teacher's role is crucial in providing students with opportunities to succeed and helping them believe in themselves.

> They (students) look at all the subjects they are learning and they internalize that... I'm good at this but I'm not good at these. [...] If a teacher however then comes in at high school and says you can do Maths let's find out where you are let's give you those successes, there can be changes. But if there are no changes at the high school level, if those preconceptions are just transferred to high school and go through then you've just wiped out a generation of Māori and Pasifika scientists, mathematicians (M5)

3.6.5 Limited exposure to Māori or Pasifika role models in engineering

Out of the twenty-two interviewees, six commented that the low numbers of Māori and Pasifika in engineering is both a result and cause of the lack of Māori and Pasifika role models in society. Some interviewees commented on the role of the media in promoting and showcasing Māori and Pasifika role models, which unfortunately is not the case, as the stereotypical view of engineering is often represented.

> I haven't read any articles or anything about those people having those sorts of jobs. (F15)

> It's about whether or not they see themselves as a modern engineer in the modern world when they're not showing role models of how to get there. (FL21)

Acknowledging the impact of family role models in children's goal setting about the future, interviewees commented that children are more likely to follow careers that adults in their family have followed. Interviewees argued that if parents or other family members have not had the opportunity to follow an engineering or similar career, children are not likely to believe that this is an option for them and see themselves doing it either. "I suppose if your parents haven't had the opportunity to go into those things or they've had that kind of taken away from them, they (children) might not follow that career path" (F6)

In many cases parents and wider family follow careers that fit the stereotype as they are also influenced by society's expectations. They then become role models for the children in the family who in turn don't see professions that are not represented in their extended family and community as an option for them.

If there are family members who had been in it (engineering) or are in it [...] that's then introduced to you as an option in the first place. (F13)

4 Overview Discussion

The results of this study indicate that interviewees' views of engineers and engineering align with stereotypical views suggested by Godwin et al. (2016) that engineers are analytical thinkers who are good at maths and science and with Barnard et al. (2012); (Reilly, 2012). Weber (2012) stated that the engineering profession mainly attracts males and females a generally less interested. These ideas are also supported by Cheryan et al. (2015). The data also suggests that that stereotypical views of engineers can stop some girls from considering engineering as a career (Dresden et al. 2017).

Diversity is reported by Ahmed et al. (2019) and Weber (2012) among others as desirable characteristic for the engineering profession. Gender balance increases diversity, however the USA engineering profession is still only made up of 20% female (Dresden et al., 2017). England, New Zealand and Australia reflect similar patterns. An interesting point raised from the data is the idea that girls are just 'not –interested' in engineering. This point-of-view was expressed by a number of interviewees such as F11 who stated "That would reflect my experience, [I was] just as not as interested, even though, I did well in calculus, physics", M7 who said "Maybe females feel like engineering isn't a strong female based profession". However, M5 recognises that these attitudes start young and may be cultural rather an innate.

> Because I've got a daughter and a son and my daughter and certainly not because we're pushing but she loves the dresses and the dolls and the Disney characters and all that kind of stuff. My son is 2 and he'll walk over and grab a car, there might be 20 things and he'll grab a truck or car and make noises. So how are we as parent's kind of encouraging that to continue? Whereas if my son is in the backyard and he'll come over and spin the wheels and I encourage that. Whereas if my daughter comes and says it's dirty and I stay away. So I think there are elements of that happening

Gutierrez et al. (2017) stated that technically capable female students with altruistic motivations currently tended to prefer medical, or social care roles

over engineering or STEM. This study supported this stance and aptly illustrated by F4 “[Engineering is] very male dominated and [...] seen as a male job, just like teaching is seen to be for females because of the nurturing side”

However, good engineering practice is highly sociable and requires excellent communication. Ultimately, engineering has service to society as a core motivation. Hence, care must be taken to ensure that technically capable students with altruistic personalities are not diverted from considering engineering as a career. However, the data from this study seems to imply that prejudice in career recommendations is likely to be occurring. This prejudice was aptly illustrated by F10: “Males go towards engineering and females go towards teaching”

Seventeen interviewees in the study thought that teachers were influential in students’ selection of career. Parents, peers and social media also featured with decreasing frequency (Table 5). These results only partially align with the literature (Kazi & Akhlaq, 2017; Krumboltz et al., 1976; Lamb et al., 2017; Lloyd et al., 2018), stating teachers have some influence on career selection, but are not the greatest influence. However what is interesting is that when asked about influence on career selection all interviewees mentioned people or groups of people whereas Lamb et al. (2017), Ahmed et al. (2019), Godwin et al. (2016) and Weber and Custer (2005) suggest individual personal characteristics such as perceived ability, interest and self- efficacy are also very influential. This may be due to question 1.4 of the interview asking ‘who’ rather than ‘what’ influenced the interviewees choice to become a teacher. Nonetheless, by asking ‘who’ the societal influences could be better elucidated. As teachers have considerable impact of students’ self-perceptions of their ability and interests (Martin, Marsh, McInerney, Green, & Dowson, 2007; Zee & Koomen, 2016) we suggest that teacher influence on students’ career selection is multi-faceted and greater that current literature suggests.

The data also highlighted by omission a number of gaps in the interviewees’ understanding of engineers and engineering practice. Only one interviewee

independently identified that engineers need to be social, and several stated that they did not need to be social, nor communicate well. Only a few of the interviewees mentioned the need for collaboration and for engineers to be reflective. No one mentioned engineers needing empathy nor the need for consideration of the environment or sustainable practices. No one suggested that kind, caring and empathetic children would make good engineers, nor were girls specifically mentioned, although boys were. This is problematic as these are the skills highlighted in the literature as necessary to meet the changing demands of an increasingly complex engineered world (Du & Kolmos, 2009; Schäfer, 2006).

The methodology used in this study included mixed qualitative interviews and quantitative surveys. However, the quantitative arm of the project effectively failed to produce valuable data and thus triangulation was threatened. Ultimately, this led to the main limitation of this study: the lack of triangulated data sources. However, using two cohorts of students from two different universities in two different islands of New Zealand went some way to address this, so too did the addition of lecturers to the data pool.

Importantly to further address this lack of triangulation, an updated, novel (according to the knowledge of the authors) triangulation approach enabled a high level of confidence in the interpretation of the data. In particular, while quotes were gathered and interpreted by the primary author of each section, the interpretation was blinded and other authors interpreted the quotes for themselves. In most cases, interpretation was consistent across authors and no change was needed. However, in some cases the interpretation of the primary author was challenged. In such cases, the subsequent discussion led to consensus that all authors considered an improvement on any primary interpretation. This outcome is partially supported by the socio-cognitive conflict theory.

The qualitative interviews were generally well received by the interviewees. The authors felt the interview gave a strong impression of the interviewee's

understanding, bias and prejudice of engineers and engineering practice. The data set was very rich, and more analysis beyond those contained in this report were possible. Some important research questions cold be imminently addressed with the data set yielded:

- How did student teachers link engineering and the technology curriculum?
- What were the interviewees' personal reasons for avoiding STEM careers?
- Did the student teachers consider the culture of engineering practice unsuitable for female participation?
- How did the interviewees' personal circumstances that lead to their opinions, biases or prejudice?

However, this report addressed what the authors felt were the most important questions: Did the student teachers understand engineering sufficiently to facilitate appropriate career recommendations to their students? and was there any bias or prejudice evident in their responses? The interviews uncovered a broad range of responses and a diversity of opinions in the student teacher cohorts.

5 Recommendations

5.1 Recommendations for education

This research yielded a number of very important factors when considering female, Māori and Pasifika participation in engineering.

- Section 3.1 – Very few student teachers had a generally acceptable concept of engineering. Some had an incomplete understanding of engineering practice. But most student teachers had a very poor understanding of engineering practice.
    - The researchers recommend that teachers must become versed in the general nature of engineering, and the primary and secondary subjects, attributes and dispositions that contribute to successful engineering practice. One may assume that the lack of understanding in student teachers ultimately disempowers them from encouraging appropriate students into engineering. One may imagine that similar gaps in knowledge exist for many other professions. Hence, we recommend that any intervention deriving from this research describes engineering to the student teachers, but also other professions. For example, it may not be consistently known that mathematics knowledge is critical for builders, and builders without basic numeracy are ultimately unsuccessful. Students would benefit if teachers were able to situate the curriculum within authentic vocational and professional contexts.

- Section 3.2 and 3.3 student teachers yielded very stereotypical views of the types of people that go into engineering practice. These stereotypical views were persistent when even close family members contradicted the stereotype.
    - Ultimately, society should challenge stereo-typical views and help mitigate the effects of harmful stereotypes that ultimately lead to prejudice in career recommendations. The engineering sector has a responsibility to showcase engineering in a way that attracts a wider diversity into engineering.

  The stereotypical views held by a minority of incumbent teachers could potentially be extremely harmful to career aspirations of malleable students. It is hoped the typical altruism of incumbent teachers lead them to be receptive to direct teaching on matters of subconscious bias and the effects of stereotyping in career selection

- Section 3.4 – Student teachers generally recognise that they may have at least a minor influence on the career choices of their children. However, this was not universal.

    - Student teachers should be made aware of the considerable influence they will have on their students' career aspirations and their students' self-efficacy. In particular, for children with challenging backgrounds, or non-aspirational families, teachers may be the only influence capable of encouraging upwards social mobility.

- Section 3.5 – most student teachers noted that the historical precedent of male imbalance in engineering practice has led to a variety of problems for female participation. In particular, the lack of female role-models, and the perceived difficulty of engineering culture on females were noted as barriers. There were also misconceptions around precisely what engineering was, with some avoiding the profession as they thought it was ultimately a greasy, muddy job (which it is not!).
    - Alongside the recommendations to inform student teachers about what the nature of engineering, female engineering role models should be introduced to the student teachers. Perhaps female engineers should present engineering content to the teachers. While this may seem contrived or possibly tokenism, student teachers will always have at least one female engineer that they have met, and this may be enough to choose to encourage their female students to consider engineering. This lack of visibility of female participation in engineering was exemplified by FL22 when asked to describe an engineer 'I suppose to be honest, first up will be as a male figure because that's who mostly is out there and I have never, [actually] I have met one, young female engineer. Everyone else related to engineering has been male'. Note this this was a lecturer with more life experience than the other interviewees.
    - While there is significant intra-gender variance, females have a slight tendency to have a greater interest in humanitarian aspects of engineering practice, and have a mild preference to go into more social fields. While engineering practice is perhaps less social than medicine, or law, it is about as social as architecture, which has a much smaller male bias (~58%), and arguably fewer humanitarian possibilities. Hence, any outreach that targets increased female participation in engineering should highlight the significant good that engineering can do for people and the climate, and also the need for strong communication skills in engineering practice.

- Section 3.6 – most student teachers noted a general tendency for cultural, whānau and personal disinterest in engineering and other STEM subjects among Māori and Pasifika. An interest in sporting and cultural education was also noted. Others noted economic barriers to achieving academic prerequisites for tertiary engineering education. However, perhaps most worryingly, one polite and well-spoken student teacher expressed a view that Māori and Pasifika were not mentally equipped for engineering training "[Engineering] is kind of seen to be for certain types

of people and you have to have a certain way of doing things and brain for it". This type of incidental racism in otherwise seemingly respectable individuals is incredibly damaging (It is much easier to ignore someone that is not respectable).

- **The authors would like the reader to consider this the strongest recommendation from this study.** Racism and racial bias in education should be utterly, and vehemently opposed. In this study we found one student who seemed to harbour deleterious views, (or at very least, say unwise things around race issues). While this may seem a positive result from an entirely statistical point of view, one must note that this student teacher is likely to have a significant influence over 30 students, for 45 years of their career (n=1350). Hence, there should be direct teaching by education providers around issues of unconscious bias and the significance of its effect on the careers and lives of minority groups.
- Despite earnest efforts, the government and New Zealand education system is ultimately failing its obligations under the Treaty of Waitangi when it comes to Māori health and education statistics. Increasing Māori participation in well paid professions, such as engineering, should be considered a critical element of the solution to the economic disparity observed and its knock-on effect to health and education. Hence, teachers and student teachers should be explicitly instructed in both their ability to achieve upwards social mobility in Māori and Pasifika, but in also how to empower all students, including those who may not be inspired into professional careers at home.
- It is important for student teachers to be provided with opportunities to reflect on unconscious bias, especially their own. The study of certain cases as a group or as a whole class can be a good way of achieving this. Student teachers should also be required to undertake an anonymous unconscious bias test (for example: 'first year education'). Individual results should be blinded to ensure proper engagement. The cohort outcomes would provide opportunities not also for interesting discussions, but also for re-construction of one's own beliefs and unconscious biases in a group environment. Ideally, such an initiative should also consider unconscious bias with respect to professions. For example, some interviewees incorrectly assumed that engineering did not require communication skills and thus had bias around the nature of engineering and its impact on the career recommendations they give their students.

5.2 Possible form of intervention

Teachers have a critical role in our society, but are very heavily burdened not only with daily teaching but also extra-curricular activities, and the

bureaucratic burden. Hence, any intervention should be as light as possible, but aim to have the maximum impact on the gaps identified in this research. We propose the following:

In the final year of the teaching degree – possibly as a block over 3-4 days,

- 1hr lecture slot dedicated to the influence that teachers can have on student career choices – including concepts of upwards social mobility.
- 1hr lecture slot (minimum) dedicated to unconscious bias and its ability to negatively affect student aspirations. Special mention should be made around Māori, Pasifika, refugees, and first generation New Zealanders, and also genders in non-traditional roles (i.e. male nurses or female engineers). This may be undertaken within current inclusion and diversity courses with the addition of extended unconscious bias content that considers the biases and prejudices that can occur with respect to various professions. This will expand on current unconscious bias training that centres predominantly on ethnicity, culture, sexuality and disability.
- 2hr lecture slot (minimum), explicitly teaching student teachers what certain careers are, and also how the New Zealand curriculum prepares students for these roles. If possible, role-models should give these presentations, rather than tertiary education staff. However, if role models are difficult to obtain, video or written resources that provide explicit information on careers could be provided. Such resources could also be distributed to schools to aid in the career modules that are supposed to occur from year 7 of the New Zealand curriculum. However, video or written resources would need to be updated frequently to ensure that the information is up to date. This research has shown the lack of knowledge about engineering in particular, but one may also expect similar ignorance around professions with similar gender/ethnic imbalance such as accounting, nursing, building and trades, counselling, physiotherapy, pharmacy, law, police, military, primary teaching etc.

This intervention was designed with an assumption of high level of resourcing available, but limited time in the teacher education curriculum for content delivery. However, if there is no time found in the teacher education curriculum, novel methods for content delivery must be determined. It is critical that any intervention reaches the students that have poor understanding of careers or bad attitudes around diversity issues. However, such students may tend to avoid such measures, and providing material for voluntary engagement is unlikely to prove beneficial. Hence, the content must be delivered in such a way that all student teachers must engage. For example, it may be possible to require

all students to watch a video and successfully answer an online quiz on the content before being allowed to go onto placement or graduation.

Enforced, but individual engagement with the type of online resource and evaluation described is likely to have a small positive effect. However, this secondary recommendation should be considered inferior to the initial recommendation. The socio-cognitive conflict theory implies that discussing this type of content in a cohort is a very efficient way of changing false views. Also, there were some participants that mentioned they had never met a female engineer. Hence, the appearance of such role models in the classroom would have a profound affect not available over video.

5.3 Recommendations for researchers in similar research

- Consider if small augmentation of interview scripts can lead to much broader and impactful research outcomes. In particular, this research could potentially have asked more about proximal careers, and more explicit information around other occupations with disproportionate populations and perhaps more targeted interventions could be designed.
- Carefully consider the potential outcomes of survey data and Likert scale tests. In retrospect, the survey abandoned in this study failed to yield any profound findings. Even if the survey participants had interesting things to say, the survey would not allow extraction of this information. More preliminary testing should have been undertaken before the survey was sent to the ethics committee.
- Do not necessarily focus on the voice of the majority responses, or be too interested in summary statistics. In this study, perhaps the most important recommendation came from the outlier who voiced deleterious opinions that should not be allowed into the education sector.
- Use reputable transcribing services. The authors spent a lot of time referring to the original audio file and fixing some strange transcription.

6 Conclusions

This research is positive step towards assessing the causes and possibly reducing inequality and increasing diversity in engineering. It highlights stereotypical views of engineers held by our future teachers. As well as working with those making decisions that will alter their career aspirations, work also needs to be undertaken to ensure teachers have accurate perceptions of the full scope of the engineering profession and debunking stereotypical ideas that shroud it. The data from this study suggests that various elements of society can inhibit female, Māori or Pasifika participation in the engineering profession. This is very aptly illustrated by F13

> Right now am just sort of imagining of a big forest and if someone hasn't cut through that path before it's hard to want to walk through it and, yeah I think that's a big problem with young girls wanting to get involved in engineering. They don't have those female role models that have gone down in engineering path; to actually have those conversations with them; you know talk about their experiences and maybe the things that [they are] concerned about with interest. Just breaking down those barriers or misunderstandings like with those role models then it will be easier then. The question is “how do you get in there in the first place?”

The question posed by F13 was appropriate according to her experiences. However, there are currently a large population of successful female engineers, and thus, the role models do exist. The problem is providing timely access to such role models at key times. Remediation to the primary teacher education curriculum may help future teachers understand engineering and the diversity of individuals who would succeed and thrive in engineering disciplines. The teachers may then be more able to portray notions of the engineering profession, potentially leading to a more diverse cohort of people considering engineering as a career. This diversity would be expected to more comprehensively deliver the diverse needs of society (Schiebinger, 2008).

There is much work to be done in addressing the lack of diversity in engineering. This study suggests that the primary teaching workforce is one place to start.

Further research recommended would include an intervention programme for teachers, to increase their understanding of the diversity of tasks that make up engineering. Measuring impact of such an intervention on the teachers and their students' understanding of engineering could be of some interest in this field and potentially influence future career decisions.

7 Acknowledgements

The authors would primarily like to thank Ako Aotearoa and in particular Bridget O'Regan for their ongoing support, advice, and patience to allow us the significant extension necessary to complete the analyses we felt were important.

We would like to thank the Heads of the Schools who allowed the research team to recruit from their student cohorts. Unfortunately, ethical restrictions regarding interviewee anonymity forbid us for being more precise with our acknowledgement.

We would like to thank all of the interviewees. We appreciate the honesty and vulnerability that you provided the project. We hope that your sacrifice can lead to an improvement in how students are encouraged in career selection.

We also would like to thank those that volunteered, but were not randomly selected to participate; and also those who provided definitions of engineering.

Finally, thanks if you're still reading this! Your time is valuable, and we hope that this report offered some benefit in exchange for your time and consideration. The authors would be happy to hear from you and discuss any element of the report you have an interest in.

8 References

Ahmed, M. M., Basantis, M., & Jahan, K. (2019). *Reflecting on 20 years of attracting women intp engineering (AWE) workshop*. Paper presented at the ASEE Annual Conference & Exposition Tampa, Florida.

Bandura, A., Barbaranelli, C., Caprara, G., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Developmen, 72*(1), 187-206. doi:doi:10.1111/1467-8624.00273

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-Efficacy Beliefs as Shapers of Children's Aspirations and Career Trajectories. *Child Development, 72*(1), 187-206. doi:10.1111/1467-8624.00273

Banks, F., & Mayes, A. (Eds.). (2001). *Early professional development for teachers*. London: The Open University Press.

Barnard, S., Hassan, T., Bagilhole, B., & Dainty, D. (2012). They're not the girly girls: an exploration of quantitative and qualitative data on engineering and gender in higher education. *European Journal of Engineering Education, 37*(2), 193-204. doi:1080/03043797.2012.661702

Cadaret, M. C., Hartung, P. J., Subich, L. M., & Weigold, I. K. (2017). Stereotype threat as a barrier to women entering engineering careers. *Journal of Vocational Behavior*(99), 40-51. doi:https://doi.org/10.1016/j.jvb.2016.12.002

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in Psychology, 6*(49). doi:10.3389/fpsyg.2015.00049

Crotty, M. (1998). *The foundations of social research*. Sydney: Allen and Unwin.

Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, techology engineerig ans mathematics: STEMing the tide and broadening particpation in STEM careers. *Behavioral and Brain Sciences, 1*(1), 21-29.

Di Nardo, F., Casagrande, F., Boemi, M., Fumelli, P., Morosini, P., & Burattini, R. (2006). Insulin resistance in hypertension quantified by oral glucose tolerance test: comparison of methods. *Metabolism, 55*(2), 143-150.

Dresden, B. E., Dresden, A. Y., Ridge, R. D., & Yamawaki, N. (2017). No Girls Allowed: Women in Male-Dominated Majors Experience Increased Gender Harassment and Bias. *Psychological Reports, 121*(3), 459-474. doi:10.1177/0033294117730357

Du, X., & Kolmos, A. (2009). Increasing the diversity of engineering education – a gender analysis in a PBL context. *European Journal of Engineering Education, 34*(5), 425-437. doi:10.1080/03043790903137577

Duncan C., Bell T. and Atlas J.. (2017) What do the teachers think? Introducing computational thinking in the primary school curriculum. In *ACM International Conference Proceeding Series*: 65-74. http://dx.doi.org/10.1145/3013499.3013506. (Conference Contributions - Published)

E2E. (2019). Girl's aren't well represented in marketing materials. Engineering education to employment. http://engineeringe2e.org.nz/casestudy/education/show/112

E2E. (2019). Waikato-Tainui Partnership. http://www.engineeringe2e.org.nz/casestudy/education/show/114

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2016). Identity,critical agency, and engineering: An affective model for predicting engineering as a career choice. *Journal of Engineering Education, 105*(2), 312-340. doi:.1002/jee.20118

Gutierrez, C., Paulosky, M., Aguinaldo, A., & Gerhart, J. (2017). Women break an engineering barrier. *IEEE Pulse, 8*(6), 49-53. doi:10.1109/MPUL.2017.2750818

Hill, C., Corbett, C., & St Rose, A. (2010). *Women in science, technology, engineering, and mathematics* (978-1-8799-2240-2). Retrieved from https://eric.ed.gov/?id=ED509653

Hill, M., & Thrupp, M. (Eds.). (2019). *The professionla practice of teaching in New Zealand* (6 ed.). Melbourne: Cengage Learning Australia Pty Ltd.

Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching, 42*(6), 668-690. doi:https://doi.org/10.1002/tea.20069

Jones, G., Taylor, A., & Forrester, J. H. (2011). Developing a scientist: A retrospective look. *International Journal of Science Education, 33*, 1653–1673. doi:https://doi.org/10.1080/09500693.2010.523484

Kazi, A. S., & Akhlaq, A. (2017). Factors affecting atudents' career choice. *Journal of Research and Reflections in Education, 11*(2), 187-198.

Koppel, M. B., Cano, R.M., Heyman, S.B. (2002). *An attractive engineering option for girls*. Paper presented at the 32rd ASEE/IEEE Frontiers in Education Conference, Boston, MA

Krumboltz, J. D., Mitchell, A. M., & Jones, G. B. (1976). A social learning theory of career selection. *The Counseling Psychologist, 6*(1), 71-81.

Lamb, R., Annetta, L., Vallett, D., Firestone, J., Schmitter-Edgecombe, M., Walker, H., . . . Hoston, D. (2017). Psychosocial factors impacting STEM career selection. *The Journal of Educational Research, 111*(4), 446-458 |. doi:https://doi.org/10.1080/00220671.2017.1295359

Lloyd, A., Gore, J., Holmes, k., Smith, M., & Fray, L. (2018). Parental influences on those seeking a career in STEM: The primacy of gender. *International Journal of Gender, Science and Technology, 10*(2).

Low, K. S. D., Yoon, M., Roberts, B. W., & Rounds, J. (2005). The Stability of Vocational Interests From Early Adolescence to Middle Adulthood: A Quantitative Review of Longitudinal Studies. *Psychological Bulletin, 131*(5), 713-737. doi:10.1037/0033-2909.131.5.713

Martin, A., Marsh, H., McInerney, D., Green, J., & Dowson, M. (2007). Getting along with teachers and parents: The yields of good relationships for students' achievement motivation and self-Esteem. *Australian Journal of Guidance and Counselling, 17*(2), 109-125. doi:10.1375/ajgc.17.2.109

Mitts, C. R., & Haynie III, W. (2010). Preferences of male and female students for TSA competitive events. *Manufacturing Systems, 853*, 27.

Nguyen, D. Q. (2000). The status of women in engineering education. *International Journal of Engineering Education, 16*(4), 286-291.

Reilly, D. (2012). Gender, culture, and sex-typed cognitive abilities. *PLoS ONE, 7*(7), 16. doi:10.1371/journal.pone.0039904

Schäfer, A. I. (2006). A new approach to increasing diversity in engineering at the example of women in engineering. *European Journal of Engineering Education, 31*(6), 661-671. doi:10.1080/03043790600911738

Schiebinger, L. (2008). Gendered innovations in science and engineering.

Spencer, S. J., Logel, C., & Davies, P. G. (2015). Stereotype Threat. *Annual Review of Psychology, 67*, 415-437. doi:https://doi.org/10.1146/annurev-psych-073115-103235

Vaughan, K. (2018). *Engineering e2e: An evaluation*. New Zealand Council of Educational Research. http://engineeringe2e.org.nz/assets/e2e/discoveriespdfs/c236cc5036/Engineeringe2e-evaluation-Feb-2018.pdf

Vygotsky, L. S. (1978). *Mind in society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.

Weber, K. (2012). Gender differences in interest, perceived personal capacity, and participation in STEM-related activities. *Journal of Technology Education, 24*(1), 18-32.

Weber, K., & Custer, R. (2005). Gender-based preferences toward technology education content, activities and instructional methods. *Journal of Technology Education, 16*(2), 55-71.

Zee, M., & Koomen, H. M. Y. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: a synthesis of 40 Years of research. *Review of Educational Research, 86*(4), 981–1015. doi:10.3102/0034654315626801

9 Appendices

9.1 Information sheet and informed consent form for interview participants

Research Information Sheet

Dr. Paul Docherty
College of Engineering
University of Canterbury
Telephone: +6433692230, Internal Phone: 92230
Email: paul.docherty@canterbury.ac.nz
23 March 2018

ITE students' perceptions on certain careers: Assessing potential for bias in the formative career decision years.

Information Sheet for Interview Participants

We are Dr. Paul Docherty, University of Canterbury and Associate Professor Wendy Fox-Turnbull, University of Waikato. We are undertaking a research project in the field of the career selection support for young people. Prior research suggests that children aged 11-13 years can be influenced significantly by their teachers.
We are hoping to interview final year primary teacher education students and their lecturers to determine their perceptions, attitudes and beliefs about different careers. We would like you to consider being a participant in the study. In particular, you are asked to consider your availability for a structured individual interview which will take 30-45 minutes. A $50.00 voucher will be provided at the completion of the interview. Interviews will be audio recorded which will be subsequently transcribed and collated with responses of your colleagues for analysis.
In the performance of the tasks and application of the procedures there are only risks are anonymity and confidentiality. To mitigate these risks participation is entirely voluntary, and you have the right to withdraw at any stage without penalty. You may ask for your raw data to be returned to you or destroyed at any point. If you withdraw, we will remove information relating to you. The results of the project may be published, but you may be assured of the complete confidentiality of data gathered in this investigation: your identity will not be made public without your prior consent. To ensure anonymity and confidentiality, participants who are interviewed pseudonyms will be used in all material made publicly available. Furthermore, the cohort (year) and university that the respondents come from will be anonymised. They will be referred to as College N (North Island) and College S (South Island). Pseudonyms only will be used always through the data analysis and presentation phases. All data will be secured in either Dr Docherty or AP Wendy Fox-Turnbull's locked offices or

password projected computers for a period of 10 years after the study and subsequently destroyed. Professional transcribers will sign non-disclosure agreements and transcribe the interview audio. All data from the transcribers will be retrieved at the end of the transcription process.

This project has been reviewed and approved by the University of Canterbury Educational Research Human Ethics Committee, and participants should address any complaints to The Chair, Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you agree to participate in the study, you are asked to complete the following consent form and return it to either Paul Docherty or Wendy Fox-Turnbull. Please indicate to the researchers on the consent form if you would like to receive a copy of the summary of results of the project.

Yours sincerely,

Paul Docherty Wendy Fox-Turnbull
Dr. Paul Docherty Associate Professor Wendy Fox-Turnbull,
University of Canterbury University of Waikato.

Consent Form

Dr. Paul Docherty
College of Engineering
University of Canterbury
Telephone: +6433692230, Internal Phone: 92230
Email: paul.docherty@canterbury.ac.nz
23 March 2018

ITE students' perceptions of certain careers: Assessing potential for bias in the formative career decision years.

Consent Form for Lecturers and Student Teachers

Include a statement regarding each of the following:
I have been given a full explanation of this project and have had the opportunity to ask questions.
I understand what is required of me if I agree to take part in the research.

- ☐ I understand that participation is voluntary and I may withdraw at any time without penalty. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain practically achievable.
- ☐ I understand that any information or opinions I provide will be kept confidential to the researcher and transcribers of interviews and that any published or reported results will not identify the participants or their institution.
- ☐ I understand that all data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form and will be destroyed after 10 years.
- ☐ I understand the risks associated with taking part and how they will be managed.
- ☐ I understand that I can contact the researchers Dr. Paul Docherty at paul.docherty@canterbury.ac.nz and Associate Professor Wendy Fox-Turnbull at wendy.fox@waikato.ac.nz if required.
- ☐ For further information, or if I have any complaints, I can contact the Chair of the University of Canterbury Educational Research Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz)
- ☐ I would like a summary of the results of the project and am happy to provide my email address
- ☐ By signing below, I agree to participate in the interview.

Name:_Signed:_____Date:__

Email address (for future contact)

Please return this form to Dr. Paul Docherty or Associate Professor Wendy Fox-Turnbull at the above emails or personally.

9.2 Information sheet and informed consent form for interview participants

Research Information Sheet

Dr. Paul Docherty
College of Engineering
University of Canterbury
Telephone: +6433692230, Internal Phone: 92230
Email: paul.docherty@canterbury.ac.nz
23 March 2018

ITE students' perceptions on certain careers: Assessing potential for bias in the formative career decision years.

Information Sheet for Interview Participants

We are Dr. Paul Docherty, University of Canterbury and Associate Professor Wendy Fox-Turnbull, University of Waikato. We are undertaking a research project in the field of the career selection support for young people. Prior research suggests that children aged 11-13 years can be influenced significantly by their teachers.

We are hoping to gather the views of final year primary teacher education students and their lecturers to determine their perceptions, attitudes and beliefs about different careers. We would like you to consider completing a questionnaire which should take 5-10 minutes to complete. We hope to recruit a cohort of 50-60 respondents from both University of Canterbury and University of Waikato. Upon completion and return of the questionnaires, we will put you in the draw to win one of ten $50.00 shopping vouchers at each university.

During the completion of the questionnaires, there are only risks are anonymity and confidentiality. To mitigate these risks participation is entirely voluntary. Upon submission, your participation will be recorded to allow entry to the voucher draw and your submission will be anonymized and pooled immediately upon receipt. This anonymization means that you will not be able to recover your submission as the investigators will not know which submission to remove.

The results of the project may be published, but you may be assured of the complete confidentiality of data gathered in this investigation: your identity will not be made public without your prior consent. To ensure anonymity and confidentiality, participants who are interviewed pseudonyms will be used in all material made publicly available. Furthermore, the cohort (year) and university that the respondents come from will be anonymised. They will be referred to as College N (North Island) and College S (South Island). Pseudonyms only will be used always through the data analysis and presentation phases. All data will be secured in either Dr Docherty or AP Wendy Fox-Turnbull's locked offices or

password projected computers for a period of 10 years after the study and subsequently destroyed. Professional transcribers will sign non-disclosure agreements and transcribe the interview audio. All data from the transcribers will be retrieved at the end of the transcription process.

This project has been reviewed and approved by the University of Canterbury Educational Research Human Ethics Committee, and participants should address any complaints to The Chair, Educational Research Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you agree to participate in the study, you are asked to complete the following consent form and return it to either Paul Docherty or Wendy Fox-Turnbull. Please indicate to the researchers on the consent form if you would like to receive a copy of the summary of results of the project.

Yours sincerely,

Paul Docherty Wendy Fox-Turnbull

Dr. Paul Docherty Associate Professor Wendy Fox-Turnbull,
University of Canterbury University of Waikato.

Consent Form

Dr. Paul Docherty
College of Engineering
University of Canterbury
Telephone: +6433692230, Internal Phone: 92230
Email: paul.docherty@canterbury.ac.nz
23 March 2018

ITE students' perceptions of certain careers: Assessing potential for bias in the formative career decision years.

Consent Form for Lecturers and Student Teachers

Include a statement regarding each of the following:
I have been given a full explanation of this project and have had the opportunity to ask questions.

- ☐ I understand what is required of me if I agree to take part in the research.
- ☐ I understand that participation is voluntary and I may withdraw at any time without penalty. Withdrawal of participation will also include the withdrawal of any information I have provided should this remain practically achievable.
- ☐ I understand that any information or opinions I provide will be kept confidential to the researcher and transcribers of interviews and that any published or reported results will not identify the participants or their institution.
- ☐ I understand that all data collected for the study will be kept in locked and secure facilities and/or in password protected electronic form and will be destroyed after 10 years.
- ☐ I understand the risks associated with taking part and how they will be managed.
- ☐ I understand that I can contact the researchers Dr. Paul Docherty at paul.docherty@canterbury.ac.nz and Associate Professor Wendy Fox-Turnbull at wendy.fox@waikato.ac.nz if required.
- ☐ For further information, or if I have any complaints, I can contact the Chair of the University of Canterbury Educational Research Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz)
- ☐ I would like a summary of the results of the project and am happy to provide my email address
- ☐ By signing below, I agree to participate in the interview.

Name:_Signed:_____Date:__

Email address (for future contact)

Please return this form to Dr. Paul Docherty or Associate Professor Wendy Fox-Turnbull at the above emails or personally.