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A New Zealand National Outreach Program – Inspiring Young Girls in Humanitarian Engineering

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***Abstract* – The representation of women in the Science, Technology, Engineering, and Mathematics (STEM) education and professions fall far short of their representation in other various disciplines. Finding ways to increase underrepresented populations in STEM fields continues to be a major initiative in education. Outreach programs that demonstrate the social benefits of engineering are an effective way to engage students' interest and enhance their understanding of the theory and practice of science and engineering. This paper describes the design of an outreach program that provided a learning experience on the nature of engineering (via community service activities) to school girls aged 10 to 13 years in New Zealand. The objective of the program was to raise aspirations of young girls to pursue a career in engineering, by demonstrating the social benefits of engineering and thus develop enthusiasm for STEM subjects applied in the context of humanitarian engineering. The strategies for improving similar outreach programs and the lessons learned are also discussed.**

Index Terms - Humanitarian Engineering, Outreach programs, Women in STEM

Introduction

Currently, engineering education globally is having a resurgence. The Royal Academy of Engineering[1] reports that the UK will require "1.28m new science, engineering and technology professional and technicians by 2020". In Australia, a Senate inquiry[2] was set up to address the shortage of engineering and related employment skills. In the interest of their economy's recovery, the American Immigration Council[3] is calling for new policies to improve Science, Technology, Engineering and Mathematics (STEM) training throughout the U.S. educational system. In New Zealand (NZ), a consortium of tertiary providers have developed a national plan, called the National Engineering Education Plan (NEEP), aimed to provide NZ with a significant increase in the number of engineering graduates. There is particular urgency to achieve this in NZ, as the percentage of registrations (6.6) in tertiary engineering qualifications is low in NZ comparative to other countries such as UK (8.2), Australia (10.4), Japan (16.1) and Finland (25.9)[4].

These figures highlight the growing need for engineers to support various economies across the globe. However, this needed growth is a complex issue. It is not just about encouraging more young people to embark on a career in engineering it is also about recruiting a more diverse section of society.

There is an under representation of females practicing engineering where women barely reach 10% of the profession's cohort. For example, there is approximately 9.8% in Australia[5], while it is 18% in US[6]. In NZ, women are slightly more represented in the

profession where a study carried out by the Institution of Professional Engineers New Zealand[7] showed that just 13% of professional engineers and 16% of engineering technicians were female. The stereotype of engineering being male-dominated has been shown to be a key barrier to girls and young women taking up careers in the engineering profession[8]. As Fadigan and Hammrich[9] pointed out,

> *As a group, women are minorities in Science, Technology, Engineering and Mathematics (STEM). When compounded with other risk factors, such as being labelled as a racial or ethnic minority, low socio-economic status and non-traditional family structure, women are placed in a position which does not favor their success in traditionally white, male-dominated fields (pg. 836)*[9].

In summary, the profession needs to address its image problem and the earlier we can affect young girls' perceptions the better.

This paper describes how we are addressing this balance in NZ; through a national outreach program which persuades young girls that engineering can be a viable career option for them. Research shows[10] that women are more inclined to the study subjects they find "socially relevant", and more likely to be motivated by the idea to study engineering if they could "make a difference"[11]. We believe that by being very explicit about connecting engineering with its benefits to the society it will help address both gender disparity and increase general interest (irrespective of gender) in engineering. Through their study, Beanland & Hadgraft[12] also suggest that by demonstrating the social benefits of engineering to young people (girls and boys) it will raise their aspirations to pursue a career in engineering. Brown et al.[13] also opined that marketing campaigns targeted at school-aged children could highlight how STEM fields give back to the community or help others in an age-appropriate way. Thus, outreach programs that are aligned with a "social/human" focus (humanitarian engineering) could help in recruiting women into engineering disciplines.

Our outreach program is a pilot funded by the NZ Ministry of Business, Innovation and Employment (MBIE) and was conducted during July to December 2016. Our project collaborated with the UNESCO UNITWIN (United Nations Educational, Scientific and Cultural Organization's University Twinning Network) in Humanitarian Engineering of which the authors' university, Massey University, is a founding partner. The aim of UNESCO UNITWIN in Humanitarian Engineering scheme is to promote an integrated system of research, training and information on humanitarian engineering to enhance cross cultural learning and sharing[14]. The founding partners of the UNITWIN span the globe: Coventry University in UK, Massey University in NZ, Institute of Accountancy Arusha in Tanzania and the University of Malta. In the following sections we will outline our approach to the design of the program and summary of our key findings.

Recruitment of Young Girls to the Outreach Program

This section outlines our approach taken to engage with young girls (aged between 10 and 13), from low socio-economic communities, with the aim of showing that a career in engineering is an opportunity for girls as well as boys. We have targeted this age group because of several reasons. Many of the education consultants' reports have documented the importance of motivating students from primary through the secondary school years because of the trend of declining attitudes to mathematics and science with age[15]. There are many examples in those reports of initiatives at primary school stage, as well as initiatives directed

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at enhancing STEM participation in higher education, and STEM research and development interventions. In their report, Marginson et al.[15] show that in Western Europe and the United Kingdom, the United States and Japan, considerable attention is paid to primary school mathematics and science research and development interventions. In Australia there has been growing realization of the importance of the primary and lower secondary years in determining students' intentions to continue or not with STEM-related subjects and careers. There is considerable evidence that student experience and developing intentions through these years are strongly indicative of their eventual choices[16]. The implication of this is clear – that if we are to help students to keep open the possibility of STEM subjects and eventual career choice, then the mathematics and science experiences prior to the early middle years of schooling need to be positive and engaging, and students need to be made aware of the range of people and activities comprising STEM work in society.

To ensure we sparked interest from this target group of young girls, we took an unusual approach about how we marketed our program. Typically large/national outreach programs targeted at girls tend to have a similar marketing approach. Usually the name of the program has some connotation with science or technology and it is very clear from the outset that the program supports STEM. For example, "Techbridge"[17] began as a program of the Chabot Space & Science Centre in California, which "inspires girls to discover a passion for technology, science and engineering. Through hands-on learning, we empower the next generation of innovators and leaders". We specifically marketed our program so that on first impression girls would not associate it with engineering or technology. We call this "engineering education by stealth". For example, we have purposely chosen the name "Hello Café"[18] as we wished it to convey a welcoming program in an environment that is relaxed and friendly. Our brand is fun, using colors that young girls can typically connect with (Figure 1).

FIGURE 1
THE BRANDING OF THE OUTREACH PROGRAM

To ensure we attracted girls we understand that you can't just rely on the brand we also have to get our brand and message out to the girls and their influencers, such as parents and teachers. Hence we worked closely with a national initiative called "Futureintech", which offers a no-cost service to schools around NZ that promotes careers in technology, engineering and science. As part of their activities they recruit early career professionals working as engineers (as Ambassadors) to visit schools. Futureintech has six regional facilitators that cover various parts of the country, who were the main link between local schools to recruit girls into the Hello Café program. These regional facilitators circulated Hello Café posters among schools and parents which encouraged girls to register for the

program. We also extended invitations to the girls' extended family members (i.e. mothers, dads, caregivers), providing an opportunity for the wider community to see how engineering can benefit both girls and boys and society overall.

Due to time constraints the marketing campaign only ran for three weeks and resulted in 175 girls applying to attend the Hello Café program. We were impressed by the interest due to such a short campaign. Also, we were oversubscribed as the program was a pilot it had limited spaces for 120 girls. The program was held in eight venues across NZ with each one having a capacity of 15 girls. The conversion rate from applicant to attendee was excellent with total 116 girls actually attended with most venues being oversubscribed. Overall, we had a consistent attendance record at approximately 80% attendance.

Women as mentors

As education researchers'[19,20,21] suggest that using women role-models that are younger and early-graduants are effective for attracting girls to STEM programs. Adopting this strategy for our program, we recruited young woman professional engineers, who are currently at an early career stage of working within the industry to facilitate each Hello Café. These facilitators were recruited from Futureintech's Ambassador Scheme. It was envisaged that each venue would have two women Ambassadors to conduct the ten week program, and therefore originally we expected approximately 16 women to support the eight venues. Whilst in general, the coordination with Futureintech to recruit young professional women engineers (Ambassadors) has been very good, we have had a few issues particularly with recruiting Ambassadors in certain areas such as in small rural communities. For example, in Ashburton that has a population around 33,000 we couldn't find more than one young female engineer. However, we had a large number of ambassadors that volunteered to help in other regions. In total 74 women engineers were recruited to facilitate the Hello Café workshops. This excludes another 15 engineers who were on stand-by if required. The actual contribution of volunteer facilitators has been overwhelming as their time equates to approximately $100k that has been given in support of the program. There were a range of engineering disciplines and sectors represented by the Ambassadors such as: electrical, product development, civil, mechanical design, water, structural, environmental, drill/petroleum, automation, and geothermal.

Whilst the Hello Café program is focused on inspiring young girls an indirect benefit has been that it has helped the women Ambassadors develop professionally and personally. For instance, they have identified challenges such as: being able to explain technical details to school aged girls in their language; how to manage a group to stay on task; being organized and planned in the workshop; having full responsibility for a young group of people; "thinking on their feet" when dealing with tricky questions. Other benefits came from as increased profile for themselves and their company with regards to community engagement. In addition, some have identified gaining better public speaking skills.

Venue

Since the environment where students engage with STEM affects young women's perception[9], the venues where the Hello Cafés operated were extremely important. Fadigan and Hammrich's[9] study identified that providing a secure, stable, comfortable, "out-of-school" environment is particularly useful for those who live in low-income, single-parent families. They also proclaimed that informal science institutions such as museums and libraries could afford a positive experience for young women. This out-of-school approach has also been proposed by more recent research when analyzing science engagement and

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literacy for Indigenous and non-indigenous students in NZ and Australia[22]. By considering the aforementioned reasons we chose to select venues that were easy to reach, relaxed, inspiring, out-of-school and collaborative spaces in order to breakdown any barriers for engagement. Consequently, we purposefully chose to use museums, art galleries or libraries to hold the Hello Café program.

HELLO CAFÉ PROGRAM DESIGN

Hello Café is a free national afterschool club, where girls of 10 to 13 years old meet over 10 weeks to help solve problems faced by communities that need help. This Hello Café concept is adopted from a well-proven outreach program that has used humanitarian engineering focused workshops to successfully engage young people into engineering. Our UNESCO UNITWIN collaborator, Coventry University, has trialed these workshops to various age groups such as 14-17, and 19-21 years old (irrespective of gender) and includes young people who are either excluded or at-risk of school exclusion, and newly arrived to the UK as refugees, or asylum seekers.

The Hello Café program adapted these existing workshops to ensure that they were appropriate for a younger audience and also had a NZ context. The program consists of 10×1.5 hour workshops that have been specifically developed to focus on the social benefits of engineering. Each workshop was practical and "hands-on" and allowed time for discussion.

The overall concept of the design of the suite of 10 workshops is that we approached engineering and technology in an indirect manner. During each workshop we gradually built the girls' connection with engineering by focusing on "helping people first", rather than using "engineering" as the focus; again using this "engineering education by stealth" strategy. We wanted the girls to come out of the experience excited and amazed about what engineering could do and more importantly where they felt confident that they could actually "do" engineering by having real hands-on experience of solving problems (Figure 2). We wanted them to challenge the stereotype that engineering is "dirty" and it's what men do. We wanted them to feel that they can break-down what society thinks about what young girls should do by having long-term, continued support from a real woman engineer who became their mentor.

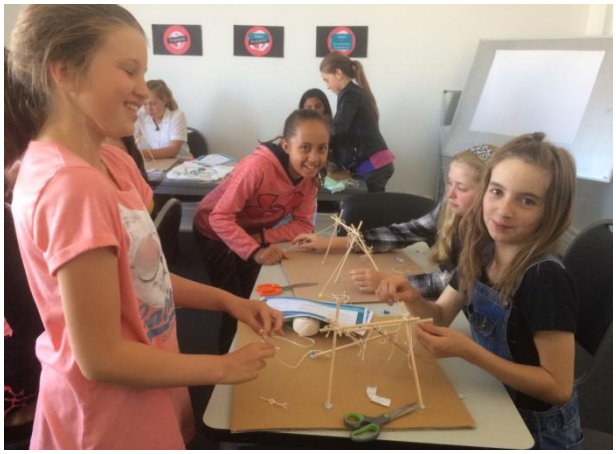

FIGURE 2
THE GIRLS MAKE SHELTERS AS A PART OF THE RELIEF SHELTER WORKSHOP

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Engineering Workshops

Each workshop in the program has been funded and developed by a team of professional engineers and practitioners who work in the humanitarian aid field. These workshops were developed with the support from Royal Academy of Engineering in UK, Practical Action (an international development charity), industry, academia, private and non-governmental organizations.

Each workshop in the program has been designed for a problem-based learning approach, where a student is not a passive receiver of knowledge but is actively engaged in the learning process. The learning occurred in a group scenario with many opportunities for students to complete activities. Another important aspect is that by focusing on issues that highlight social and cultural needs (both in NZ and developing countries) it was hoped that students could see themselves as represented in the work and believe that what they do makes a difference to their lives and others. These aspects have been highlighted as crucial in engaging with children, particularly those on the margins[23].

Table I summarizes the ten workshops. A crucial connecting theme has been around the UN's Sustainable Development Goals.

TABLE I
DESCRIPTION OF TEN WORKSHOPS

	Workshops	**Description**	**Aims and outcomes**
1	Design for a Better World	This workshop is designed to emphasize on the importance of United Nations Development Goals. By the end of this workshop students will be able to discuss the key issues facing humanity and how technology can help.	• Learn about the Global Goals for Sustainable Development. • Access a range of global contexts including Water and Sanitation, Food Security and Climate Action. • Explore a range of technologies that people are developing around the world to address Global challenges.
2	MOJA Island	This workshop is designed to emphasize to the students the importance of becoming more creative in terms of producing energy in a more sustainable and environmentally friendly way. In support of Global Goal 7.	• Explore the concept of Technology Justice and how renewable, locally sourced sustainable energy solutions enable people to work their way out of poverty. • To identify the most appropriate renewable energy option for island communities.
3	Disaster Proof Road Systems	This workshop is designed to emphasize on the importance of transportation systems. By the end of this activity students will be able to look at a town map and seek improvements of its transport systems in very different realistic areas. In support of Global Goal 11.	• Describe what a transportation system is • Explain its importance - Nepal before & after • Explore who is responsible for it and how it can be improved particularly when things go "Wrong". • Evaluate transportation systems both in Kalanza & Newtown.

4	Trash to Treasure	This workshop is designed to emphasize to the students the issue of plastic waste and becoming more creative in terms of reducing and reusing waste in sustainable and environmentally friendly way. In support of Global Goal 12.	• Explore the issues around plastic waste and where it goes. • To appreciate how waste can provide income opportunities for communities. • Encourage the making of products from waste plastics.
5	Clean Water for Life	This workshop is designed to illustrate how important clean water is to communities throughout the world by using a practical design activity to show how different countries have access to resources to improve water quality. In	• Gain an understanding of water consumption on a local and global scale. • Learn about the main water contaminants and various methods of purification. • Inspire an interest in water conservation.
6	Relief Shelter	The Relief Shelter workshop helps students to identify the main issues with current relief shelters and explore the advantages and disadvantages of reciprocal frames.	• Examine the importance of shelters to refugees and displaced people. • To be able to describe the construction of reciprocal frame. • To explain how to use a reciprocal frame to build a shelter structure. • To analyze the benefits of a reciprocal frame structure over other designs.
7	Beat the Floods	This Beat the Flood workshop helps students to identify the main issues of flooding and to allow them with the necessary tools and information to create their own flood-resistant house.	• Be able to describe who is most affected by flooding in communities around the world. • Design flood resistant houses for a community in need.
8	Building with Earth	This activity is designed to emphasize to the students the importance of revisiting some traditional building techniques that are far more sustainable and environment friendly. In support of Global Goal 11.	• To be able to relate to the properties and usage of common building materials. • To explain the advantages of building with earth worldwide. • To describe the disadvantages of rammed earth construction and devise ways to overcome these.
9	Power a Healthy World	Power a Healthy World is a hands-on enquiry based workshop enabling students to explore renewable energy solutions in the developing world with a focus on wind turbines. In support of Global Goal 7.	• Describe how renewable energy can provide power in rural communities on a global scale • Design and build a wind turbine and test it to find out whether it works.
10	Design a Loo	This workshop is designed to emphasize on the importance of sanitation to students. In support of Global Goal 6.	• Examine the role sanitation has played in world development. • Critically evaluate a range of sanitation systems from around the world. • Design suitable sanitation systems for a range of case studies.

There have been studies on how to attract girls to science, engineering and technology, e.g. Little and León de la Barra[19], Daly et al.[24] and Bamberger[25]. Daly et al. as well as Little and León de la Barra opined that practical, hands-on, small group activities; the use of informal settings and time for discussion are the key attributes for successful engagement. In addition, Bamberger highlighted the importance of using women role-models that are younger and early-graduants and building relationships with role-models through long-term

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interactions for successful engagement with young girls. We used said attributes to design our program.

Each workshop contained facilitator support sheets, PowerPoints, kit sets and student support materials. In addition, there was online "train-the-trainer" resource support. Table II shows an extract from a facilitator support sheet that provides a step by step "teaching plan" to help the women engineers deliver a particular workshop.

TABLE II
EXTRACTS FROM THE FACILITATORS' SUPPORT SHEET - POWER A HEALTHY WORLD

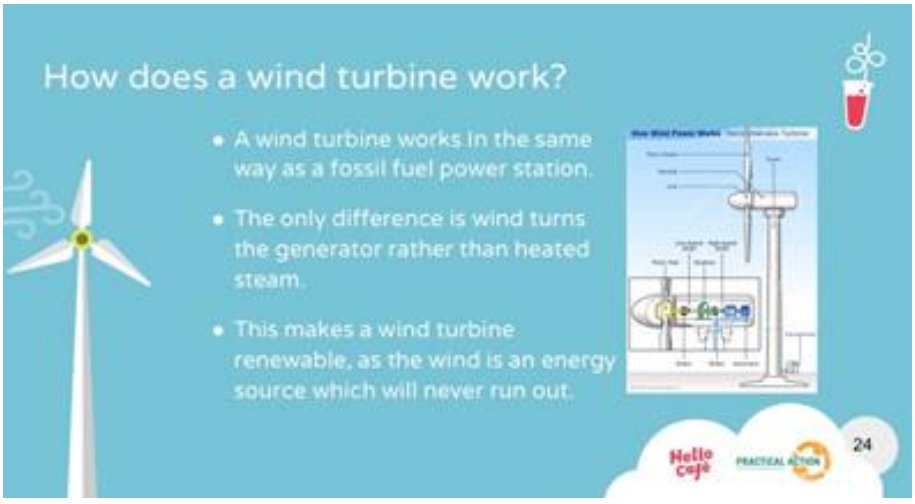
Timing of Session

A recommended time breakdown is provided below.

	Activity	**Slides**
0-10	Session 1 - Introduction, ask the question "Do you think that electricity is important for all?" Record % Plus quiz	1-5
10-25	Session 2 - How is electricity produced? The use of fossil fuels. What is being done about this problem?	6 - 14
25 – 50	Session 3 - Model the National Grids of NZ & Kenya. Discuss Technology Justice and show video.	15 - 23
50 – 1hr 20	Session 4 - Activity - Build a wind turbine.	24 - 27
1hr 20 – 1hr 30	Session 5 - Finish the session and ask question again "Do you think that electricity is important for all?" Remind students to bring their mud brick to the next workshop 'design a loo'	28 - 29

Session 4

30 mins. Slides 24-27



TIP - Try get across the benefits of wind power and that this is a great renewable technology that could be used in developing countries. This links in nicely with the earlier Session 2, as it can be used on a small scale to provide electricity to those not connected to the national grid and that wind energy is renewable.

Ask the students - How does a wind turbine work?

The same as a conventional power station, but instead of steam turning the generator, wind does. Thus a wind turbine generates renewable energy.

The main point to stress is that a wind turbine is built to be fit for purpose. As this slide comes just before the next Activity, Ambassadors should discuss how a wind turbine with many blades is better for Mechanical work (i.e. lifting objects) compared to a 3 bladed one used for generation of electricity.

For more information: http://energy.gov/eere/wind/how-do-wind-turbines-work

Survey Questionnaire and Data Collection

A survey questionnaire was used to explore girls' understandings and perceptions of engineering before and on completion of the Hello Café program. This survey was based on the survey developed by Erkut and Marx[26]. The questionnaire consists of three sections and simple introductory page. The introductory page covers general information about girls and how to complete the survey. The Section One of the questionnaire checks how they rate their capability in English, mathematics, and science. Addition to that it also explores whether they know what engineering is. Section Two covers 23 statements related to attitudes towards mathematics, science, and engineering; and explores good pedagogies of learning. The final section (Section Three) explores the career aspirations. The post-survey was identical to the pre-survey and contained an additional question on *what words would you use to describe your experience at the Hello Café* and attitudes towards the things that they have enjoyed about being part of the Hello café.

The attitude[1] towards mathematics, science and engineering scales were adapted from Erkut and Marx. In our adaptation, the number of items for the attitude towards mathematics was seven, for the attitude towards science was seven and for the attitude towards engineering was nine. The scales were tested for reliability. Scale reliability measures the degree of relatedness of items that belong to a construct/subject[27]. All scales had Cronbach's alpha internal consistency reliabilities over 0.74 (the rule-of-thumb cut-off value is 0.7 or higher).

The girls' participations in the study were voluntary. Prior to starting the program, we asked parents' permission to seek their daughters' attitudes toward mathematics, science and engineering. Information sheets were sent off to the parents as well as participants explaining the purpose of the Hello Café program, nature of the survey, an importance of participation, the nature of the girls' involvement, confidentiality of the data and benefits. The completed and signed consent forms were collected from the girls who agreed to participate and from their parents. There were no consequences to the ambassador, the parent or girl if a girl chooses not to participate, and any girl could stop her participation at any time. This project has been reviewed and approved by the Massey University Human Ethics Committee; the entire project was deemed "low risk".

These surveys took place at the beginning of the first workshop (10th October 2016) and at the end of the last workshop (12th December 2016) and took 20 minutes each. Prior to administering the survey, the ambassadors were given guidelines explaining the nature of the

[1] Each attitude scales were scored as 1= *Strongly Disagree*, 3=*Not Sure*, and 5=*Strongly Agree*

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survey and how to conduct the surveys. They were instructed to explain to the girls how to fill the questionnaire and especially if girls' have any questions about a statement or trouble understanding a word.

PRELIMINARY RESULTS

In this section, we discuss the preliminary results on how these workshops influenced perceptions of engineering and the career attitudes of the girls who took part in the program. As mentioned earlier a survey questionnaire was used to explore girls' understandings and perceptions of engineering before and on completion of the Hello Café program. Out of the 116 girls, 104 agreed to participate the surveys. The largest ethnic group of these girls was NZ European, NZ Maori, Other, Pacifica, Samoan, Chinese, Indian, Cook Island Maori, Tongan, and Niuean. The responses for other included Dutch, Japanese and Tokelauan. The girls ranged in age from 10 to 13; the mean age was 11.38. The response rate of the pre-survey was 89% while it was 73% for the post-survey. The reason for the lower response rate was the period that the last workshop conducted. The last workshop held during the Christmas season and especially it was the last school day of the fourth term. Some of the girls had gone on summer holidays. Thus comparative to the other workshops the participation rate of the last workshop was low.

In the pre-survey, 53% of girls said that they know what engineering is, whereas 14% of them said they have no idea what engineering is. Nevertheless, on the completion of the program, this 53% figure had increased to 84%, while the 14% figure decreased to 0%. The survey asked if the girls could identify six different types of engineering. The pre and post survey results were 3% and 62% respectively of girls that said yes that they could identify six different types of engineering. These findings reflect that girls were able to better understand what engineering is after the completion of the program.

Survey results showed significant increment on the following statements: "I feel as capable as the boys when tackling technical problems" and "Engineering skills will allow me to make society better". This may indicate an increase in confidence in dealing with technical issues and that they clearly see a link between engineering and social benefit. The results also showed that the Hello café program has positively affected the girls' perceptions of learning habits. For example, in the pre-survey, the girls reported disagreeing or highly disagreeing with the following statements: "I like to have hands-on activities", "I like the chance to have lots of discussion and debate", "I like having guest speakers talk to us about their subjects" and "I am confident about communicating in a group". After participating in the workshops with young professional female engineers, they reported positive attitudes towards those habits. This finding also suggests that the girls' perceptions of learning techniques have been enhanced as a result of their participation in the program. In addition, attitudes towards mathematics were explored. For example, in the pre-survey, 3.19% of girls strongly disagreed with the statement which asked "are you good at mathematics". However, on completion of the program this figure had gone down to 0 which emphasizes the attitudinal increase of young girls towards mathematics.

The girls loved the workshops with over 93% of the girls, when rating each of the 10 workshops, gave a rating of "Awesome". The two favorite workshops were the Trash to Treasure and the Clean Water for Life. The top four things (in descending order out of 9 options) the girls really enjoyed about being part of the Hello Café (measured in the post-survey): the lots of hands-on activities and building things; working on problems that can really help other people and communities; being in a place out of school; and getting to know

the Ambassadors – real engineers and scientists. This result supports previous studies on attributes for successful outreach programs i.e. venue, mentors, and hands-on activities.

Over 90% (sample of 75 respondents in the post-survey) of girls would tell others about their experience at the Hello Café. Most girls explicitly stated that they had great learning experiences at the Hello Café. Girls used vivid phrases like *"Awesome learning experience. I might do it again next year", "I enjoyed the activities. Fun and it educated me", "Really interesting and fun. I loved building and making things", "I had the most exciting moments, time with the ambassadors and with the girls" ,"It was fun meeting real engineers and working with other people", "It was really good learning about practical problems and solutions", "It was amazing! Over my time at Hello Café I learnt so much! I will definitely be back next year".*

In the pre-survey, 21% of girls said that they were interested in being an engineer when they leave school, whereas 16% of them said they are not interested. However, on the completion of the program, this 21% figure had increased to 30%, while the 16% figure decreased to 9%. In addition, career aspirations were explored. What was interesting that out of a list of 19 different careers (e.g. media, law, and education) in the pre survey science was listed in the top 3 careers. However in the post survey, science dropped to 9th place, with engineering being in the top 3.

This decline in interest in science as a career may be due to the design of the workshops. On reflection, we didn't make it explicit in the workshops that engineering is based on science subjects. It may also be difficult for young girls in general to appreciate the usefulness of science, because they may be too young to associate school science with their daily lives in a meaningful manner. In addition to that, anecdotal evidence from speaking to school teachers in NZ, it seems that teachers use different words such as "enquiry topic" and "themed study" instead of "science" when discussing subject (science) related concepts at primary and early secondary schools. This impression can be supported in that some girls explicitly stated on their survey replies that they do not learn science at school. For example, they stated "*we don't do science at school*". Although tenuous, this evidence may suggest that terminology used in the schooling system isn't helping attitudes towards science.

CONCLUSIONS: GENERAL LESSONS LEARNED

Preliminary results have shown that the girls generally improved their understanding of what engineering is and what engineers do. They also learnt more about women in engineering and the accompanying goals and values of the profession. The outreach program had a noticeable influence in changing these young girls' perceptions of engineering when considerations on societal goals and values were made. Overall, several features led to this program's success. One of the important program elements is the type, amount, environment, and quality of the workshops. The topics addressed in the program are made to be interesting and challenging in a way that many of the girls had never experienced. This program's instructional approach, which centers around group work and hands-on learning with fun in a supportive environment, surfaced as a key program element. The program's methods of instruction and comfortable environment seemed to differ from those girls encounter at school, and based on their comments, they felt that the program environment better suited the needs and learning styles. Finally, we found that the young professional engineers (Ambassadors) are another strong component of the Hello Café program. For instance, the role-model aspect of this program to include Ambassadors helped the girls see themselves as potentially successful engineers in both the present and future. Several parents said that their daughters began talking about the importance of engineering and were now considering

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engineering careers after the program ended. To quote a parent *"My daughter is going around telling her friends that did you know more engineers save lives than doctors….whilst this is great it's the fact that my daughter wouldn't have used the word engineer 3 months ago and now we can't shut her up".*

We cannot underestimate the importance of having these early career women engineers facilitating the workshops. It's their energy and enthusiasm that paints a positive picture about a career in engineering. An overwhelming response by the engineering women community to be involved. To quote an Ambassador from one of the regional Hello Café groups "*Thanks I feel very privileged to have been involved and have loved every moment of it! One of my girls gave me flowers and chocolate to say thank you and I tried not to let the tears out, lots of hugs and smiles, the parents all came in and watched their daughters receive their certificates and clapped etc. it was beautiful, my dad took photos of each of the girls with their certificates too so looking forward to uploading them all to the google drive. I got an offer from the local community trust that is very keen to help fund the program if we don't receive government funding, they can easily offer up to $10,000 so please keeps in touch about how everything works out! I would love to be involved again if I can.*"

Another key finding is that online registration may hinder access to low socio-economic groups. Our main format for registration was to use the Hello Café website. It became very apparent that this format for registration wasn't in a form that was easy for some parents to access. If girls from low socio-economic background are a target group then there has to be many formats to ensure accessibility. For instance as well as online registration a paper based system may also be used. These paper forms could be directly sent to parents or teachers in schools. Or there may be an opportunity to get the Ambassadors to visit the schools and begin the registration process.

A consideration when designing a national outreach program that is to be delivered by a large group of people that are remote from each other and the overall design team is to have extremely detailed workshop instructions for the program facilitators. In addition it is important to have facilitator packs to be professionally produced; preferably by a creative agency. This enables each workshop to have consistent branding and layout, allowing instructions to be easily followed by a diverse group of facilitators. By producing workshop materials to such quality they can be easily replicated and rolled-out to any number of centers across a country and used with ease by multiple numbers of facilitators that are from any discipline or experience.

We strongly recommend that facilitating hands-on activities with fun in engineering should be accompanied with messaging that clearly conveys how engineers help people and reach societal goals and values. Finally, we suggest that although casting engineering in a "social benefit" light can inspire girls to have an interest in an engineering career we recommend that any outreach activity makes a distinct connection to the science principles behind engineering.

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