Outreach programmes using the Triple Helix model to encourage interest in Science and Technology among underrepresented youth

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Abstract

Science and Technology entrepreneurship is one of the requirements of the new millennium, an era called digital society and globalization. Entrepreneurship is considered an agent of growth, wealth creation and development of society. Although New Zealand has experienced a rapid growth of education and research in Science and Technology areas, the country continues to face challenges in engaging communities such as Māori and Pasifika school students. There is a lack of understanding about career pathway choices and opportunities by parents and high school students, especially in these communities (Ministry of Business, 2014). A significant part of enhancing this understanding is building a relationship between the communities, science and technology industry partners and school students.

This paper presents an initiative taken by the university, government and community partners to create a better understanding of science, technology, engineering and mathematics (STEM) and entrepreneurship. The programme brought together business, government, researchers, school students, and the wider community within the Auckland region. It demonstrated the application of the triple helix model (Figure 2) to connect the three major players through STEM subjects and entrepreneurship. The programme encourages students to think about themselves as job makers rather than job takers in the future. A range of measures are used to evaluate its success, and initial results are presented. The format of this study can serve as a guideline for future initiatives aimed to improve students' awareness of STEM and entrepreneurship careers.

Key words

STEM; Entrepreneurship; New Zealand; Triple Helix Model; Māori and Pasifika.

Introduction

Science and Technology entrepreneurship plays a vital role in the growth and development of the economy and society. Science, technology, engineering and mathematics (STEM) is critical for enhancing living standards through economic growth and improving social and environmental outcomes. This can be possible when the government works closely with communities in designing educational policies and initiatives that can lead to job creation and self-reliance.

To lay a strong foundation for future generations and the 21st century economy, educators and decision makers must continue to promote STEM education opportunities. With the shift in demographics to include more diverse populations, we must realise the need to establish a good and supportive system for underrepresented segments of society. They contribute to future growth, so we must recognize the economic impact of not moving in this direction. Many of the western countries have recognised the importance of diverse and underrepresented communities and believe that inclusion through collaborations and considerations of social and cultural aspects is paramount (Figueroa, 2015). However, there are still gaps that separate underrepresented communities from the mainstream who are able to take advantage of the technology and STEM education and opportunities that exist in areas such as education, employment and health (Alam & Imran, 2015). Research also shows that barriers such as social esteem, financial status and culture can incite data disjuncture and a failure to adopt and embrace innovation (Lu, Meng, Guo, & Huang, 2013).

New Zealanders are known for their 'do it yourself (DIY)' and can-do attitudes towards problem solving and career planning. Youth need more support and guidance to engage in key areas of STEM subjects now and in the future (Ministry of Business, Innovation and Employment, 2014), especially Māori and Pasifika (indigenous and minority communities in New Zealand- NZ). In recent years, the NZ government has designed and supported initiatives to encourage and promote STEM subjects through the Ministry of Business, Innovation and Employment (MBIE), Ministry of Education (MOE) and the City of Manukau Education Trust (COMET) Auckland. They are funding educational projects in collaboration with universities and communities. This reflects an excellent example of a triple helix model used to promote STEM education, by bringing together business, government, researchers, students, and the wider community. This paper presents one such government initiative, called Unlocking Curious Minds by the MBIE to promote STEM education among school students, Auckland University of Technology (AUT), Māori and Pasifika communities and South Auckland schools and colleges. This article explores the best way to connect with underrepresented communities in the STEM area. The article outlines various approaches used to connect with the Māori and Pasifika communities, workshop activities with school students, and presents the outcomes. This study can serve as a guide for future initiatives to engage with underrepresented communities in order to improve students' interests in STEM

and entrepreneurship. The article provides an overview landscape of NZ's underrepresented communities in STEM and also presents an initiative taken by the university, government and community partners to create a better understanding of STEM and entrepreneurship.

Engaging with Underrepresented Communities and Technology

The last 30 years of research involving technology, especially in STEM fields, has demonstrated some significant differences in gender and race among the participants (Charleston, George, Jackson, Berhanu, & Amechi, 2014). Statistics have shown that not all diverse and indigenous groups experience the same level of quality of participation in STEM across the world (Alam & Imran, 2015). Differences in culture, language, education level, age, socio-economic conditions, learning styles, communication style, family values and other factors influence the adoption of technology (Alam & Imran, 2015; Bianco, Cunningham, & McCombe, 2009; Helsper, 2008). Various scholars and practitioners have also identified similar gaps that influences the educational process of indigenous communities (Nakpodia, 2010, Gumbo, 2015). Although representation is improving, there are still gaps in the research regarding students from underrepresented communities in STEM.

It is important to integrate and encourage underrepresented communities to be part of the mainstream technology and STEM field. Modern information and communication technologies can have a positive impact on an individual's social inclusion and on the community's collective social capital as it continues to expand potential social networks and sense of belonging (Broadbent & Papadopoulos, 2013). Without access and participation, communities run the risk of remaining excluded from the mainstream and subsequently failing to integrate in society for the economic growth of the host country. The article highlights the role of technology and its important role in unrepresented communities for creating a sense of belongingness and integration in the mainstream.

Studies have showed that students discontinue their studies in STEM because of the barriers they experience in their educational journey (Long & Mejia, 2016). Some of the barriers include negative stereotypes about underrepresented minorities, educational institution barriers, racial discrimination, financial burden, lack of role models, limited numbers of mentors and insufficient support from the same race peers and faculty (Covington, Chavis, & Perry, 2017; Figueroa, 2015). Due to the family pressure, students from underserved groups often enter careers where career prospects are more obvious, stable and more easily understood by other family members (Hrabowski, 2011). Students from underrepresented communities can be adversely affected by institutional barriers as well. Many undergraduate engineering programmes also have lengthy or have rigid course requirements, restrictive admission policies and high entry costs (Long & Mejia, 2016).

A strong emphasis has been placed on increasing participation in technology and STEM areas among underrepresented populations. Even though STEM-related jobs are a growing

sector of the New Zealand economy, participation from underrepresented communities are limited. Despite many initiatives to encouraging children to think and increase participation in STEM, the numbers are still limited (Ministry of Business, Innovation and Employment, 2014).

The New Zealand Context

New Zealand is a small, geographically isolated and well-educated country. Over 94 percent of the businesses are Small and Medium-sized Enterprises (SMEs). To overcome the disadvantage of the modest size and low level of large scale industries, they must continue to maximise opportunities to harness and cultivate our ability to be competitive and innovative. The current and future generations must be skilled in technology to develop new high-value products, meet the demands of business, and mitigate and adapt to the challenges of a quickly changing world (Ministry of Business, Innovation and Employment, 2014). This puts special emphasis on future generations to educate and create a platform to meet challenges and compete on the global scale.

Apart from the size of the country, New Zealand has a very diverse population. New Zealand's population is a multi-cultural, heterogeneous group comprised of people who speak different languages and have different values. Pasifika people are those who migrated to New Zealand from the Pacific Islands and who identify themselves with the islands or cultures of Samoa, Cook Islands, Tonga, Niue, Tokelau, Fiji, Solomon Islands and other mixed heritages (Gilbert & Bull, 2013). At the same time, a declining number of skilled workers in technology fields threaten New Zealand's global competitiveness and economic growth. Low participation, representation, engagement, and inclusion continue to also reduces the intellectual capacity of the New Zealand STEM workforce.

The socio-cultural deprivation belief prevails among school and tertiary students. This point of view suits the causality clarification of imperialism and its inheritance of social and economic predominance and subordination as a key supporter of negative social belief for Māori and Pacific Islanders, including low educational accomplishment (Bishop, 2003). The deficit lens assumes that students and their families are simply not adequately prepared for higher education. This may be due to their position of family resources, lack of role models or lack of value for technology-based education.

The government in New Zealand is concerned about the decreasing number of students in STEM education (Freeman, Marginson, & Tyler, 2015). The rapid growth of these communities and increasing numbers of youth entering the work force in coming years make it vital to address these issues. Schools, colleges and universities are seeking to increase the participation of Māori and Pasifika in STEM education (The Office of Ethnic Communities, 2016).

The pursuit of STEM to drive economic growth has seen a shift in the alignment of Government agencies from single, small policy agencies such as the Ministry of Research, Science and Technology, to the creation of the Ministry of Business, Innovation and Employment (MBIE), which brings together science and innovation, economic development, immigration, consumer affairs, building and housing. The mandate of this super-Ministry is to 'be a catalyst for a high-performing economy to ensure New Zealand's lasting prosperity and well-being' (Buntting, Jones, McKinley 2015, P. 22).
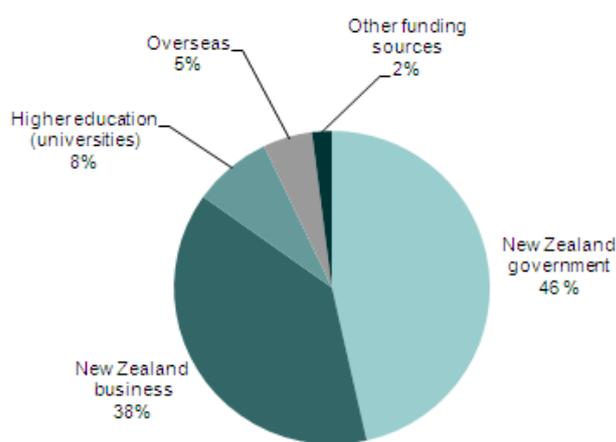

Figure 1. Research and development expenditure by source of funds (Buntting, Jones, McKinley, 2015)

As seen in Figure 1, New Zealand's expenditure on research and development as a proportion of GDP increased from 1.15% in 2002 to 1.3% in 2010, or a total of NZ$ 2.4 billion. Nearly half of this (46%) was contributed by Government. The Government is focusing on aligning its science funding more with business, community and future national needs. In spite of various initiatives and programmes, the attitudes and engagement of school and college students towards STEM subjects is much less when compared to international counterparts (Buntting, Jones, & McKinley, 2015). This is more prominent in Māori and Pasifika students. Students choosing whether or not to pursue science at their senior school or college is influenced by a variety of factors including students' experiences of learning science in and out of school, their personal interests and family background, knowledge about the range of study and career options that involve science, and possibly mathematics learning experiences.

Research Aim

The aim of this research was based on approaches to include underrepresented students and plan activities that would help enhance their aspirations towards STEM studies and

careers. Firstly, the study sought to find out how best to involve students from schools where STEM study was not their first choice. Secondly, how to engage students in a way that was relevant to their backgrounds. The next section provides a brief role of the triple helix approach used to engage and encourage STEM subjects among underrepresented communities. It also discusses some of the initiatives by New Zealand Government's outreach programmes to encourage STEM among Māori and Pacifika communities.

The Triple Helix Approach to Outreach Programmes

The Triple Helix model of working between university, industry and government is a means of enhancing the knowledge based economy (Ministry of Business, Innovation and Employment, 2014). As knowledge has become an ever more important and crucial part of innovation, universities, as institutions for the generation and dissemination of scientific and technological knowledge play a critical role in generating innovators and problem solvers.

According Etzkowitz and Ranga (2008), the evolutionary process in the Triple Helix system involves a transition from the 'statist' stage in which government controls academia and industry, to the laissez-faire state relationship between the three institutional spheres; and finally to the hybrid stage in which each institutional sphere keeps its own distinctive characteristics, and at the same time assumes the role of the others. The evolutionary process underlying the Triple Helix system is graphically depicted in Figure 2 below. Each helix is connected to another, thus assisting in the formation of interfaces between them. Industry gains some of the values of the university, sharing as well as protecting knowledge; research groups in industry would collaborate with public and university research groups to achieve common long-term strategic goals (Etzkowitz & Leydesdorff, 1995).
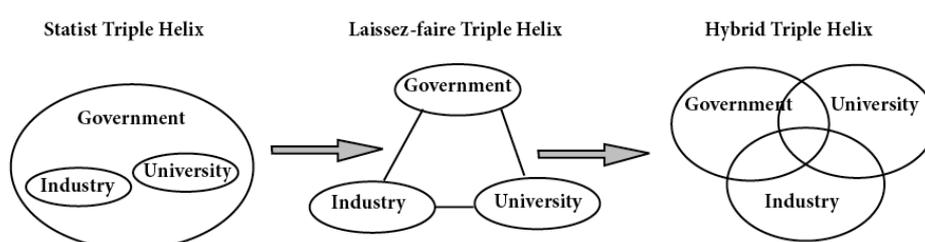

Figure 2: Hybrid Triple Helix Model (Abdrazak & Saad, 2007)

The Triple helix framework has been successfully implemented by business disciplines and many social enterprise projects. Recently, there has been some progress in engaging and encouraging a collaborative approach, evidenced in conferences and summits bringing together community leaders, educators and local and central government to develop strategies to improve opportunities and outcomes for indigenous people in STEM education and careers (Figueroa, 2013; Paige, Hattam, Rigney, Osborne, & Morrison, 2016). In this programme, we are using the triple helix framework to engage and encourage STEM subjects among underrepresented communities. Under this programme, partnerships were formed between government represented by MBIE, universities represented by Auckland

University of Technology (AUT) and community (schools and colleges). This programme is an initiative by MBIE under the banner of Unlocking Curious Minds. MBIE provided funding for conducting the programme, AUT conducted the programme in South Auckland campus and as a school and colleges from South Auckland served as a community partners for promoting and encouraging participation among their students.

The Unlocking Curious Minds is a contestable fund that supports innovative projects that excite and engage New Zealanders, particularly young people (aged 18 years and under), who have fewer opportunities to be involved with science and technology. The objective of the fund is to support projects that use innovative and/or best-practice approaches to provide New Zealanders with more opportunities to learn about and engage with science and technology, by MBIE:

- funding education and community outreach initiatives that focus on science and technology
- broadening participants' ability to engage with science and technology
- promoting the relevance of science and technology in their lives, and
- supporting them to engage in societal debate about science and technology issues facing the country.

The details of one such project, STEMpreneurial Bugs, and its outcomes and recommendations are discussed in the next section.

Method

Project Context

The main aim of the STEMpreneurial Bugs programme was to create a broader understanding of STEM by the youth of South Auckland, and link STEM to entrepreneurship. A significant part of this understanding is building a relationship and better engagement between the community, STEM industries and the youth of South Auckland region. A number of community-based science projects with local industries were developed, with involvement from South Auckland youth, university staff and students.

South Auckland is rich in culture and diversity and has a youthful population. Traditional systematic tertiary learning environment does not always connect well with such students who may learn better through doing. One of the strategies that supports education engagement is through informal hands-on workshops and interactive collaborations. Research into the low engagement of Māori and Pasifika students in STEM areas also identified a lack of understanding about career pathway choices.

The project extended the STEM "meet-up" programme based on the previous year's pilot programme. It developed a community of interest and provided ongoing support to high school students from South Auckland to pursue science education and the possibilities of

establishing start-ups in STEM areas. This was done with a series of hands-on workshops and inspirational seminars run by enthusiastic scientists, technologists and entrepreneurs in STEM fields (referred to as STEMpreneurs).

Project Implementation

The age group in all workshops was 13-18 years with an average age of 15 years; with about equal proportion of male and female participants; over 90% of participant were Māori and Pasifika; all of whom are from South Auckland schools. Students from schools in low socio-economic areas were invited to be involved in STEMpreneurial Bugs programme. These schools have a higher number of students from Māori and Pacifika communities. Parents and family members also attended and participated in some of the workshops, and watched the students. We had industry speakers and community leaders in each workshop who have started a STEM start-up company, to share their experiences and inspire the youth.

To understand and capture the context of the workshops and interaction of the participations in the workshop, an observational study method was used for data collection. It provided an opportunity to observe what students do in the workshops, their level of involvement and to capture participants' enthusiasm in the workshops. As the participants were students, there were possibilities that they may have been unwilling to discuss in an interview setting. Data was collected from all the workshops by a passive observer. It helped the researchers to understand the students' level of participation and interaction and provided clues to future interest in technology and STEM areas. Data for this paper was gathered as part of workshop activities and informal feedback provided by the participants. The workshops were meant to transform traditional classrooms from a teacher-centred instruction into inquiry-based, problem solving, discovery zones where participants engage with the content.

In all the workshops, STEM subjects were connected with entrepreneurship, and students were encouraged to think about themselves as job creators. Six STEMpreneurial workshops were run and involved technology practice through engineering designing, building and testing. Participants built wave machines using jelly beans; saw demonstrations of flying quad-copters; and designed fabric sensors using wearable technology sensors and circuits. A number of engineering alumni and passionate speakers from industry, who had successfully established their own STEM start-ups were invited as guest speakers. They acted as role models and shared their own experiences and ways to create start-ups.

The six seminar sessions were run for groups of approximately 50 young people, along with many of their parents. School teachers were also welcome to attend, along with representatives from local businesses relevant to the topic of the seminar. Around 100 people were in the audience for each presentation. This wide community engagement is important to build awareness and community interest in STEM related careers.

The workshops involved hands-on activities and physical making of prototypes (Table 1). The students formed teams of three or four and were given project briefs to work through together, after a brief introduction to the topic. The activities involved in the workshops were normal conventional engineering education, but connection was made to the indigenous cultures and social values (discussed in section 7). The engineering/ technology method of generating ideas, selecting a concept and making a simple prototype that addresses the project brief, was taught during the workshops.

Workshop examples	Tasks
Design a flying paper airplane	Design a paper airplane so it has the smoothest and longest flight.
Work with a wave machine	Build a wave machine using jelly beans, and investigate different behaviours of waves.
Puzzles Contest	Solve fun puzzles, surprising paradoxes and interactive devices in maths and statistics.
Simulation of the Monty Hall paradox	The Monty Hall statistics paradox was simulated using carton boxes instead of doors, and prizes of chocolates instead of goats and Ferrari. A computer simulation was demonstrated followed by good discussions.
Modelling the Solar System	Modelling distances in the Solar System using simple materials on the desks and floor.
Fabric sensors	Building circuits that can be used in designing sensitive fabrics or touch sensitive buttons. This is usually used in health science and for designing sports outfits.
Simulation of biological evolution	Simulation of biological evolution using soft toys, string and plastic spoons.
Game design and development	Develop and set up rules for a game using playing cards and dice. Make modifications in the rules and analyse their impact.

Table 1. Workshop activities and Tasks

The environment was abuzz with support and guidance from university staff and tutors. The interactive projects offered compelling ways to engage young people by encouraging them to think of themselves as scientists and technologists or entrepreneurs in a positive and practical manner.

Project Outcomes

This STEMpreneurial Bugs project was undertaken in 2017 with youth in South Auckland, New Zealand. The project outcomes are presented in this section. The project's aim was to create a broader understanding of STEM by the youth of South Auckland, and link STEM to entrepreneurship. Activities in the workshops were designed with an aim of enhancing the

aspirations of underrepresented students towards STEM studies and careers. In addition, the workshops and seminars were open to a wider public audience, in order to involve a wider community.

Cultural and people issues were highlighted through getting the students to think about solutions that would be preferred by different communities. They were taught to create personas, i.e. profiles and descriptions of typical users from these communities. They were asked a number of questions during the maker events on why they chose a particular design, such as 'how a quad-copter can be useful to say farmers', or 'how sensors would be useful in a garment worn by the police'. These questions were deliberately open-ended in order to get students to think of various applications of technology, contexts of use and their utility to people in society. This helped the students to relate STEM to everyday applications and understand the benefits of technical innovations.

As part of data collection, informal feedback was collected from each workshop. In their informal feedback, all participating students answered "yes" to the two main questions: "Did you like the workshop?" and "Would you recommend it to your friends?" When asked if they would come again most of them said they would, and that they would tell their friends about it. In their responses to the question "What did you like most?" the vast majority reported that they enjoyed the sessions and learnt about 'interesting stuff'. The typical comments were:

"I loved the creative aspect";
"The practical activities";
"Getting to know more people and what's in the cloud";
"Both the presentations and activities";
"Lecturers, food, atmosphere";
"Becoming an entrepreneur";
"The new things we learnt and interacting with new people";
"The competitions";
"The puzzles";
"Mix and mingle and get to know more about maths";
"Everything – you fellows are awesome!"

The support staff noted the student interactions in their teams. Some students who were quiet at the start opened up and gave suggestions on how to put things together. Facilitators observed that some students had questions about the relevance of the applications of technology such as the fabric sensors.

Suggestions to engage under-served and indigenous students in Tech-Based Projects

The lack of participation among underrepresented communities in technology and STEM area must be solved not only through encouragement and engagement of students but also

through policy and practice in educational institutions. Based on the observation data and informal feedback from all the workshops, some of the outcomes are listed below:

- Collaborate with communities has been a key ingredient in the growth and success of underrepresented students. Collaborating with local schools and colleges provided a wider exposure and increased number of participants in the workshops. This also helped to build a relationship with theSTEM department of schools for sharing knowledge and future projects.

- Encourage Māori values through design presentations and hands-on activities that fit within their traditions and contexts. For example, workshops were started by a Māori song and discussing cultural and spiritual aspects of education for creating a positive 'ahua' (to make in Māori) in the workshop. A sense of belongingness was introduced in the learning environment through whakapapa and whanau. In Maori, the whanau is the place where initial teaching and socialisation of things Maori took place. The individual was able to maintain their sense of belonging through their whakapapa or genealogical ties to of these structures in the society (Moeke-Pickering, 1996).

- Involving role models from their own communities can inspire and help students to see themselves in a positive future they can build. In our workshops, STEM entrepreneurs from the local community were invited to share their experience.

- Provide opportunities to connect STEM educators and their students with the broader STEM community and workforce especially from their own cultural background. Using the triple helix framework, our programme provided an opportunity for school teachers to connect with real world entrepreneurs and a tertiary environment.

Indigenous knowledge is enshrined in New Zealand's culture and legislation through the Treaty of Waitangi. Understanding Māori knowledge and cultural norms is essential for science practitioners in New Zealand if they are to build effective working relationships with Māori communities. To communicate and create educational values to Māori groups, scientists must first learn to engage with their values. Most of the workshops were based on Fonofale model, in which mental health is integrated with physical, spiritual and cultural beliefs (Crawley, Pulotu-Endemann, Utumpapu, & Stanley-Findlay, 1995). Crawledy et.al (1997) use the fale (house) as a metaphor with the family as its foundation and the roof representing the cultural values and beliefs that shelter the family.

- Provide projects that addressed real world challenges that can create an applied learning experience and help connect to their own cultural and social values.
- Involve young students in teams of three or four, so they have support from each other and learn from each other.
- Provide pathways for teachers to address diversity and become leaders in their

schools and colleges is also a key ingredient to attract diverse communities. One of the approaches could be to run on-campus education for teachers to equip themselves with the current knowledge in this rapid changing technology field. It supports teacher collaboration and fosters relationships that allow teachers to learn from one another.

Conclusions

The paper presents a programme of STEM outreach in collaboration with high school youth in underserved regions and university staff. The programme was designed   to expose students to STEM subjects in an engaging format, and providing information on potential career pathways. The triple helix model of working with industry, government and educators was applied in this programme. This is a well-known entrepreneurial model in business disciplines but not so common in Science and Technology education outreach programmes with industry partners.

Embedding the importance of valuing people and their cultural backgrounds, together with discussions on their practical solutions was an effective way to relate to a diverse community. Teaching technology, science and engineering by connecting it to peoples' values, ethics and cultural beliefs is critical in a global society. Similar importance has also been discussed by researchers and scholars working in this area (Nakpodia, 2010, Gumbo, 2015). It is hoped that this programme will be expanded to other parts of the country and made sustainable in the future. The active participation and feedback by partners in this programme was positive.

The basic philosophy of the programme was that by having students actively engaged in hands-on tasks in science and engineering, supported by staff, they would appreciate the link between the topics and everyday applications. The approach of involving community role-models, educators and government representatives (Triple helix model), in student team activities has proven successful through our study. The use of inclusive design activities appropriate to community backgrounds also helped in engaging young learners, as was observed during the workshops and reinforced in the feedback received from participants.

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