STEM for Women and Ethnic Communities in Aotearoa (New Zealand)

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SESSION

C4: The role and impact of engineers and the engineering profession in the wider community.

CONTEXT

In order to raise awareness of science, technology, engineering and mathematics (STEM) focused jobs in the future, educational providers need to expand their delivery methods to reach a wider audience. The women and ethnic communities have been rapidly increasing in recent years, hence an opportunity has arisen to cater to their need for STEM information and aim to increase the understanding of STEM and to build awareness of career paths in STEM areas among refugee and migrant communities in Aotearoa. There are different educational programs based on specific disciplines and they all share a single goal of using innovative methods of teaching STEM subjects to minority and under-served communities.

PURPOSE

The aim of this research is, to understand the perceived challenges ethnic and refugee groups face in adopting STEM and propose a holistic approach along with the existing community partnership in New Zealand.

APPROACH

The framework used for this paper is conceptual analysis and interview method. This paper critically examines delivery methods of STEM programs across Aotearoa. Interview with ethnic communities and their reflection is also used in presenting a holistic approach.

RESULTS

We aim is to propose a holistic approach along with community partners to encourage STEM subjects in women and ethnic communities. Recommendations are offered for ways in which mainstream educational institutes can assist in building the capacities of women from ethnic communities in partnership with community partners.

CONCLUSIONS

The future of the scientific workforce and the advancements of science are dependent on the supply of talented people in STEM disciplines.

Many students that are interested in a STEM career during secondary education ultimately do not graduate in a STEM discipline.

In particular female and minority students are even less likely to enter tertiary education intending to major in a STEM subject, but if they do so they are more likely to switch away from that STEM major before completion of studies.

Clearly this is a waste of possible STEM talent and this research makes recommendations in order to improve opportunities to develop this talent.

KEYWORDS

Outreach Programmes, Ethnic Communities, STEM Education

Introduction

The acronym STEM is fairly specific and refers to science, technology, engineering and maths. There is, however, no standard definition of what constitutes a STEM job. A recent report on New Zealand STEM issues identifies possible occupations or professions that can benefit from a strong STEM educational background. STEM jobs could be considered to include natural and physical sciences (including mathematics), engineering, information technology, health (including veterinary sciences), architecture, and agricultural and environmental. (Buntting, Jones, McKinley, & Gan, 2013).

Almost every aspect of our modern-day living is impacted by maths and science. The greatest advancements in our society from medicine to mechanics have come from the minds of those interested in or studied in the areas of STEM. Although still relatively small in number, the STEM workforce has a huge impact on a nation's economic growth, and overall standard of living. STEM jobs are the jobs of the future.

Many students enter tertiary education intending to study a particular major, but change before completion of their chosen course. This is particularly true for students commencing STEM subject courses. Women and minorities are even less likely to persist in a STEM courses than are male and non-minority students. The percentage of women and minorities employed in STEM disciplines has been increasing over recent years but there are still significant gaps remaining (Huang, Taddese, & Walter, 2000). There are possibly two reasons for this. Both groups are less likely to select a STEM study in the first place and if they do they are unlikely to remain in that subject (X. Chen, 2009).

It is clear that the importance of high level STEM subjects is seen as crucial worldwide for countries to meet their economic objectives in an extremely competitive global commercial market.

In New Zealand the last few years have seen increasing government acknowledgment of the importance of science and innovation to New Zealand's economic and social future. One result of this has been the establishment, in 2011, of a Ministry of Science and Innovation, later incorporated into the new Ministry of Business, Innovation and Employment.

Another was the 2009 appointment of Sir Peter Gluckman as the inaugural Prime Minister's Chief Science Advisor. Science education was to be a key focus of this role, and in 2011 Professor Gluckman, (Gluckman, 2011) in a paper entitled Looking Ahead: Science Education in the 21st Century, set out his view that:

"A forward-looking science education system is fundamental to our future success in an

increasingly knowledge-based world".

He goes on to explore how New Zealand's science education system could be strengthened to contribute to our development as a "smart", innovative, knowledge-oriented country, capable of addressing the serious questions we will face in the future, and how we can "engage and enthuse" younger New Zealanders in science. He makes the case for the importance maths and science and that "science literacy" should be a key focus of science education.

"New Zealand must embrace science and technology and innovative thinking as a core strategy for its way ahead. There is no doubt in my mind that a population better educated in science, whether or not they will actually use science in their career, is essential." (Gluckman, 2011)

Given these views how can we continue to waste the potential of ethnic woman to New Zealand and the contribution that they could be making to the future New Zealand Economy?

Encouraging greater female and minority participation in STEM careers provides a clear route to raising participation numbers while bringing on board an under- represented talent pool. The challenge here is not new, there have been campaigns and initiatives in this area and the

female and minority groups and participation rates have barely altered. Anything that can be done would benefit STEM professions greatly.

New Zealand's population is super diverse, reflecting the waves of different settlers from many decades. Groups of migrants have included Polynesian settlers, Europeans such as the British and the Dutch, and people from the Pacific, East Asia and South Asia Ongoing migrations up to the present time mean that New Zealand has populations of people born overseas who have migrated here, as well as diverse well-established communities who identify themselves as New Zealanders (Ministry of Social Development, 2008).

Diversity of New Zealand has rapidly increased in the last ten years with 34 percent of the current population being Maori, Asian and Pacific community. People who were born overseas form an increasing proportion of New Zealand's population. Pacific and Asian migrants' entry into New Zealand are set to rise in projections made up to 2038 (Statistics New Zealand, 2016). This has positive impacts such as filling gaps in the labour market and enriching connections, but there are also potential challenges to social cohesion that can arise through increased diversity. There are number of factors influence migrants and refugee settlement in a country (Ministry of Social Development, 2008). Recent migrants may spend more time finding a job and a place to live, learning a new language and upskilling themselves according to the employment market. These communities need support in a new environment in terms of what educational and career opportunities exist and how to go about accessing them.

There is a digital divide among refugee ethnic groups and it is based on inequalities in physical access to and use of digital technology, the skills necessary to use the different technologies effectively and the ability to pay for the services (Alam & Imran, 2015). Providing suitable opportunities, information and skills development can support refugee migrant groups and provide social inclusion in New Zealand community. The diversity is also reflected in the gender gap. The science, technology, engineering and mathematics (STEM) industries offer many job opportunities, but in New Zealand only 28 percent of these roles are held by women. While women make up 64 percent of people studying for a Bachelor of Science, the majority of those are in health subjects, with less than a quarter studying engineering and just over a third working towards a qualification in information and communications technology (ICT) (Brown, 2016).

This paper makes an attempt to understand the existing landscape of New Zealand diverse population especially women. Paper also highlights some outreach initiatives by central government and corporates, challenges and proposes a holistic approach by building partnership with the local communities of New Zealand. The framework used for this paper is conceptual analysis and interview method. This paper critically examines delivery methods of STEM programs across Aotearoa. Interview with ethnic communities and their reflection is also used in presenting a holistic approach.

Literature Review

Diverse Landscape of Aotearoa

The ethnic and cultural diversity in New Zealand has been referred as the changing mosaic. Ethnic diversity of New Zealand has rapidly increased in the last ten years. The population group of New includes Pakeha/Western European New Zealander, Maori/indigenous people, Pacific Island communities, and what is considered 'other' ethnic groups (comprising people from Asia, Latin America, Africa, Central and Eastern Europe, and the Middle East) (Ministry of Ethnic Affairs, 2013). New Zealand is the fifth most ethnically diverse country in the OECD. One in every four residents in New Zealand was born overseas, and New Zealand has one of the highest immigration rates in the world (Ministry of Ethnic Affairs, 2013) New Zealand began to experience super diversity in the mid-1990s, as the sources of immigration expanded from Pacific Islanders to include a significant proportion of immigrants from Asia (M. Chen, 2015). New Zealand also has a long history of accepting refugees, and currently has a quota to accept 750 refugees each year. The top four countries of origin are Iraq, Somalia, Syria, Sudan, Vietnam and Ethiopia. In terms of gender, there were slightly more male (56 percent) than

female (44 percent) refugees. Poor experience or outcome of refugee and ethnic affects the social and economic outcomes for New Zealand.

Super diversity means that there is no "business as usual" for any organisation or country (M. Chen, 2015). Diversity of New Zealand is not a new phenomenon, but the level of immigration occurred in the last ten years mean that those not born in New Zealand has passed the critical mass. Diversity of New Zealand has rapidly increased in the last ten years with 34 percent of the current population being Maori, Asian and Pacific community (Karmokar, 2016). Super diverse groups display strong ethnic and national identities, strong ethnic peer contacts and good English language proficiency (M. Chen, 2015). This group has endorsed integration in the society through the process of adopting the cultural and social values of New Zealand along with their values of their host country.

In New Zealand, Auckland is one of the world's most multi-cultural cities; according the 2013 Census (Statistics New Zealand, 2015), almost 40% of the city's population on were not born in New Zealand. New Zealand has become one of a small number of culturally and linguistically super diverse countries. Auckland is rich in culture and diversity, with a youthful population on, this project addresses the ques on: how can the new genera on engage in science and technology. The talent pool to diverse community is varied. Few have higher qualifications with rich experience from their home country but few haven't got an opportunity to be exposed to the education and explore their strengths and interest area. Yet, they have got strong passion and eagerness to learn and do something in a new country.

STEM: Women and Ethnic Community

It goes without saying that females are underrepresented in the STEM subjects. Women are always being in minority when it comes to STEM professions. The technology and roles in STEM are rapidly growing all over the world. New Zealand being a small country, we cannot meet the demand of the economy unless we increase the supply by preparing women to take up these roles.

Engineering is typically viewed as masculine, competitive and impersonal. These are qualities that are not aligned with our images of what women are. The more masculine the branch of engineering (e.g. mechanical) then the less likely it is that women will be attracted to it or excel with it (Stonyer, 2002). Instead women are more likely to be attracted to careers with a more social context.

The foundation of a STEM career is laid early in life with school, parental and society perceptions shaping career decisions. The transition between high school and University being a critical moment when many young women turn away from a STEM career path. A recent survey by Unesco reports that "for the cohort of graduates in education, humanities and arts, social sciences, business and law, and health and welfare, where nine out of ten countries women outnumber men" (Morley & Lugg, 2009).

Work by Aronson et al highlights that psychology in young women in their development at high school and reports that,

"Girls do every bit as well in their graded work as boys do but girls lose their confidence as they advance through the grades and will do more poorly than boys in timed tests, despite getting good grades. One reason for this loss of confidence is the stereotyping that kids are exposed to –in school and in the media and even in the home- that portrays boys as more innately gifted in maths. Without denying the fact that boys may have some biological advantage, I think that psychology plays a big part here," (Aronson, Fried, & Good, 2002)

Over the last two decades' women in New Zealand has been underrepresented in STEM fields (Thomas & Drake, 2016). It has been argued that most of the women's qualification in New Zealand have been around arts, social science and education. The women participation and employment at the senior roles in schools and various tertiary institutes is not very encouraging. IT has been found that there are very few females who are Heads of Departments (HODs) in science faculties in New Zealand universities. Universities namely, AUT, Massey

and Lincoln universities has no female staff at Head Of Department level in Science (Women, 2014). The number of women participants in these prestigious awards such as Marsden Fun and the Royal New Zealand Research Fund is very less. In 2010, out of 371 successful applicants only 33 were women (Women, 2015). Within this group of women, it is not known how many were from ethnic background.

There are initiatives aimed at encouraging women and diverse groups, such as the Maori, Pacifica Island communities to enrol in STEM subjects. On the contrary, very little is known about the initiatives targeting a group in ethnic communities, consisting of Middle Eastern, Latin American and African (MELAA) and South East Asian people to participate in STEM subjects. There are well established researches around disparity, gender gap and women in STEM but not many research and statistics that addresses women in STEM from ethnic communities. There are researches and articles on gender disparity but did not put issues of colour in the context (Thomas & Drake, 2016).

Table 1: Participation in STEM Careers (Thomas & Drake, 2016)

	European		Maori		Pacific		Asian		MELAA	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Male**	**Females**
Civil Engineers	92.1	7.9	93.8	6.3	88.5	11.5	83	17	93.8	6.3
Quality Surveyors	86.7	11.7	86.4	13.6	81.8	18.2	73.4	26.6	71.4	28.6
Industrial Engineers	92.3	6.7	88.2	11.8	100.0	0.0	76.7	23.3	57.1	42.9
Mechanical Engineers	98.3	1.7	98.6	1.4	94.3	5.7	93.7	6.3	92.9	7.1
Software Engineers	90.4	8.7	87.6	12.4	87.9	12.1	87.5	12.5	90.6	9.4
Computer Engineers	94.8	4.9	93.8	6.3	87.5	12.5	91.6	8.4	100.0	0.0
Architectural, building and survey technicians	90.9	8.3	100.0	0.0	100.0	0.0	81.8	18.2	0.0	100.0
Electrical Engineers	97.5	2.4	94.4	5.6	93.3	6.7	95.2	4.8	100.0	0.0
Fitters	97.6	2.3	90.5	9.4	86.2	13.8	89.3	10.7	100.0	0.0

Table 1, shows the representation of women in STEM area from all communities such as European, Maori, Pacific Islands, Asian and MELAA. Compared to male, the representation of women is very poor. European women have still some participation in STEM careers when compared to zero representation from Maori, MELAA and Pacific people.

However, a complete specific data on the ethnic minority women is limited by the lack of consistent follow up on these groups by various government and other responsible community organisations. The lack of data among ethnic women group has been found to be an issue in other countries as well and not limited to New Zealand. Reacher's and scholars have contributed towards discussion of women in stem but lacks statistics on women of colour.

It is evident that the general population of women are underrepresented in the STEM subjects, the ethnic community will be doubly disadvantaged in the STEM professions and employment area. Technology and entrepreneurial activities are very common interests identified in the diverse population. They have different cultural and language skill sets, social background, perspectives and ideas that can contribute to the New Zealand economy, but lack information on how to go about it and what sort of industries to be aware of and apply to. By providing guidance and networking opportunities, we can help build their confidence and STEM contacts in a new environment.

Challenges in Bringing Stem to Women and Ethnic Communities in Aotearoa

Ethnic communities experience unique challenges due to their backgrounds and have higher levels of disadvantage than the population in general. Getting employment is still the main area of challenge and, along with English language for older people and women, remains the main challenge going forward. Upskilling to the current requirements of the employment especially in the rapid changing IT environment is one of the major challenge. In addition, they may resent the public cost associated with support programmes for ethnic communities (Ministry of Social Development, 2008). It is also suggested that sometimes they are reluctant to seek help from mainstream as they perceive that these services would be unable to meet their cultural and religious needs. Nevertheless, refugees can face complex information and communication challenges that may lead to social and economic problems (Leung, 2010).

New Zealand has many ethnic communities and it is one of the complex scenario to understand the disadvantages of ethnic communities. Indigenous people, Maori's are disadvantaged in the sense of suffering past colonial injustices. Most of the Pacifica people are from Pacific Island nation who are disadvantaged by socio-economic and health outcomes. Pacific peoples have worse economic circumstances than the overall population, with the majority of Pacific peoples living in areas with the fewest economic resources (Ministry of Ethnic Affairs, 2010). Asian people are better off when compared to other ethnic communities as their number of tertiary graduates are higher than other ethnic communities. MELAA is one of the largest ethnic community that represent vulnerable refuges and migrant population. The ethnic MELAA communities arrive in New Zealand through skilled migration, family reunions and refugee status. Refugees in the MELAA group are mostly from Iran, Iraq, Afghanistan, Palestine, Syria, and Kuwait in the Middle-East (Statistics New Zealand, 2013).

However, refugees and migrants have a strong desire to seek meaningful employment and contribute to life in New Zealand (MBIE). Providing informal network and community based services are important for enduring the older and especially the younger people into the mainstream economy. In order to understand STEM practices among refugee migrants and to accommodate their needs requires a holistic approach towards educating, re-training, adopting and confidence building. Research specifically associated with migrants and refugee migrant groups implies that while digital technology is considered to be helpful for them, it can also be a barrier if it is expensive and difficult to access (Migliorino, 2010). There are many factors such as culture, language, education level, socio economic conditions and communication preference, influencing the adoption and upskilling to the STEM areas among refugee and migrants (Helsper, 2008; Mara, Babacan, & Borland, 2010). Women from these communities are discouraged from pursuing science and technology roles. This leads to a very less number of females pursuing science, maths and technology courses at tertiary levels. Things needs to be done in the MELAA and other communities to promote females to take up STEM related careers in order to promote gender equality in the workforce. There also exist stereotype mindset and workplace culture in New Zealand, particularly the long hours, lack of visible role models and transparency in pay (News, 2014).

Outreach Initiatives

New Zealand governments are putting STEM top of their agendas. In NZ Minister Joyce has recently allocated extra funding for engineering degree courses, stating a NZ need for an extra 500 engineers a year (Cumming, 2014). He is also making money available to encourage teachers to teach STEM subjects in pre-tertiary education. (Although there has been little actual activity in the latter)

In recent interview with the New Zealand Herald (Cumming, 2014) Former Minister Joyce was quoted as saying,

"Science and Mathematics will provide jobs for our children, Science and Mathematics is and will continue to be responsible for our high standard of living. Science and Mathematics will ensure that New Zealand increases its economic standing internationally."

The New Zealand Government have recognised STEM education as a vehicle for economic advancement and preparing the future generation for the rapidly changing workforce. There are efforts by the Government to promote entrepreneurship and small business development in New Zealand and within this there are also efforts to support science and technology skills among minority ethnic communities. Thus, the link between universities with the industry is encouraged in tertiary education. This is seen as a catalyst in achieving economy goals of New Zealand (Thomas & Drake, 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, which brings together science and innovation, economic development, immigration, consumer affairs, building and housing. There are many initiatives such as Girl Boss(https://www.girlboss.nz/),ShadowTechDay(http://www.voxy.co.nz/technology/5/253192) ,Unlocking Curious Minds (http://www.curiousminds.nz/actions/community/women-and-girls/) and Maker a hood (https://socialinnovation.aut.ac.nz/reinventing-south-auckland-as-a-maker-city/).

Discussion and Recommendations

By now there is a convincing body of work to demonstrate the gender gap and the low participation of ethnic minority women in STEM field. There are plenty of research efforts and initiatives undertaken by government and private organisation to encourage participation. In spite of that such efforts the results are not promising. The challenges discussed in the above sections have highlighted few issues such as lack of inclusion policies targeting ethnic minority women, different in the traditional values of a diverse women, social views and traditions about gender stereotypes, work life balance and education institutional framework. Based on the ethnic landscape of Aotearoa, we propose recommendations as a way forward to encourage participation of women and ethnic minority in STEM field.

- ***Providing resources at the right level.*** Most of the resources are directed towards tertiary institutions and universities to encourage students. The real need for the resources is in the schools and colleges. Providing some pathways for teachers to upskill in the subjects and address diversity. One such approaches could be to run on-campus education for teachers to equip themselves with the current knowledge.

- ***Changing STEM pedagogy in Tertiary Education***. Traditional theoretical science pedagogy doesn't always connect with such individuals who may learn better through doing hands-on activities. One of the strategies that support educational engagement is through hands-on workshops and getting inspired by seeing what can be achieved. These comments are not confined to any particular gender. As Richard Miller of Olin College, USA reports many modern students are highly motivated to tackle the Grand Challenges (Vest, 2008) of our age but do not see the narrow study of physics and mathematics to be the key to tackling these problems. They are often seeking to make a positive difference in the world and the lives of people. They

also do not see the study of engineering science and mathematics as being directly related to the problems that they see or care about (Miller, 2010). Miller argues that engineering curricula need rebalancing and requires students to be more involved in "maker" projects less time spent in lectures that involve learning just in case knowledge about topics that are never actually needed.

- ***Reimaging of STEM education and careers***. Little has changed in the way STEM education and careers are viewed by society. They are often perceived to be a male domain and dirty. A recent Australian report notes that students have observed that engineering and physical sciences curricula tend to be crafted with over use of masculine stereotypes and examples such as automobiles, rockets and weapons. (King, 1993). Another report from the US similarly observes that the typical engineering curriculum and culture is "at odds with the value systems of most young women and minorities and probably at odds with many talented students of any race and gender" (Blue et al., 2005). The skills required in STEM careers are many and varied and require much broader so called soft skills not just narrow technical skills. Many Universities are now moving to a far more inclusive curriculum that take into account the backgrounds, interests and views of all members of a diverse society.

- ***Encouraging women participation and employment*** in school and tertiary education in senior roles, school head, and heads of department or deans.

- ***Providing teachers and mentors that relate to diverse community.*** The values of countries of origin will have an influence on their beliefs about STEM subjects. One of the issue of gender imbalance lies with attitudes, values and beliefs in different countries. For instance, the belief in few ethnic countries that men are physically superior to women.

- ***Provide opportunities to connect STEM educators*** and their students with the broader STEM community and workforce especially from their own cultural background.

- ***The initiative for the STEM projects*** *should not only be initiated by the government but by other diverse community groups as well.*

Conclusions

The very low female representation in STEM fields is clearly not due to women lacking the necessary abilities to succeed, but relates to a range of reasons such as the lack of women studying the required subjects at school to gain entry to technical degree subjects. There is currently a requirement for strong Mathematics and Physics qualifications that deter many from embarking on a technical career. Whilst these subjects are beneficial it would be more important to create an enthusiasm and passion for STEM during school years rather than concentrating on mathematics and physics. Greater emphasis should be placed on recruitment and training of STEM qualified school teachers that could create this change of emphasis.

In addition to this STEM subjects in general, and especially engineering need to be recognised as professional worthwhile career choices by society and in particular by teachers and career advisors. If more young women were made aware of careers that can be challenging, satisfying and possibly a good fit with their value systems then an increase in the percentage of females involved in STEM could increase. Year on year this would create a multiplier effect, that as more and more women followed STEM career paths the gender balance would become more equal and a third reason deterring women following STEM careers that of careers dominated by males, would become less significant.

The second area covered in this paper relating to the difficulties that ethnic community to New Zealand have in following STEM careers in New Zealand.

Many of the recent ethnic migrants do already have technical qualifications obtained in their country of origin but not recognised in New Zealand. They are therefore not able to follow their career path here and often are forced into unskilled occupations. This seems to make no sense

when there are many technical areas that are experiencing shortage of skilled people. Mathematics and Science teachers, medical doctors and dentists for example. If their existing qualifications are lacking in some areas it would be hugely beneficial for the government to fund conversion courses to allow this sector to be able to practice in New Zealand. This could be funded by way of grants that were conditional on the migrant student completing the course and practising their career for a period of time.

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