Mechanisms by Which Indigenous Students Achieved a Sense of Belonging and Identity in Engineering Education

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Abstract

In engineering education, programs designed to increase students from underrepresented groups encounter multiple challenges, particularly in the case of students from indigenous backgrounds. In the 1990s, the University of Auckland in New Zealand faced persistently low levels of recruitment, retention, and performance of engineering students from Māori tribes. To address these issues, the University created what would eventually be called the 5R Program: Readiness, Recruitment, Retention, Role Modeling, and Research, with the explicit goals of boosting numbers of students coming into and remaining enrolled in engineering, as well as increasing academic performance levels. Between 1998 and 2011, the 5R Program was highly successful, increasing both recruitment and retention, as well as boosting performance levels—to the point that academic performance among Māori engineering students surpassed the non-indigenous engineering student population. Some Māori students went on to complete master's and Ph.D. programs in engineering.

Prior to 1998, Māori and Pasifika students experienced significant struggles in engineering education at The University of Auckland, so our research question focuses on the means by which such students within the 5R Program reached such high achievement levels, including what programmatic elements boosted their success. To explain and provide a conceptual framework for the mechanisms of inclusive excellence, we focus on a case study of the University of Auckland in New Zealand, using a published framework that includes six Engineering-for-Social-Justice (E4SJ) criteria.

Each E4SJ criterion raises critical questions that unveil different reasons why the 5R Program succeeded, and collectively the E4SJ criteria serve as a prism through which to view the 5R Program's effective retention, recruitment, and performance strategies. The paper concludes with applicable lessons for recruitment and retention programs that focus on and can be adapted for students from multiple cultural and indigenous backgrounds as well as lessons for programs that work to foster the success of underrepresented students generally.

Introduction

Broadening participation of multiple underrepresented groups in engineering education has long been identified as an important goal. In the U.S. for instance, the 2014 publication of a workshop summary co-sponsored by the U.S. National Academy of Engineering (NAE) and the American Society for Engineering Education (ASEE) identifies that "the goal of diversifying engineering education has long been recognized, studied, and subjected to attempted interventions…."[1] One speaker at that NAE/ASEE-sponsored workshop noted that literature spanning over 40 years emphasizes both the importance of ethnic diversity in engineering education and common approaches to achieving that goal. However, the percentage of underrepresented minorities in U.S. engineering education still "remains well below their percentage in the population."[1] Ethnic diversity is not the sole focus of diversity initiatives, as evidenced by a 2013 U.S. National

Science Foundation (NSF) report entitled *Women, Minorities, and Persons with Disabilities in Science and Engineering*.[2] This NSF report provides data showing that women, persons with disabilities, and individuals from three racial/ethnic groups—blacks, Hispanics, and American Indians—are underrepresented in engineering education compared to their percentage in the broader U.S. population.[2]

To understand how broadening participation of underrepresented groups in New Zealand emerged as an important goal, it is important to identify key events in recent New Zealand history, particularly the Treaty of Waitangi, an agreement made in 1840 between representatives of the British Crown and over 500 Māori *rangatira* (chiefs). Article 1 of the Treaty of Waitangi facilitated the establishment of national governance in New Zealand, yet the Treaty itself was not recognized in law until 1975, more than 120 years after government was formed in 1853. Following the 1975 recognition, a process of legal reform took place including the contemporary interpretation of the principles of the Treaty of Waitangi. These principles identified equity aspirations and a process of cultural redress, which precipitated change in every facet of government service delivery including education. Thus the second report of the Tertiary Education Advisory Commission (2001) identified obligations to encourage high achievement and success for Māori; build the capability of Māori society, business and industry; develop a Māori tertiary-education (postsecondary-education in the U.S.) workforce; provide culturally supportive, and empowering learning outcomes to ensure collaboration across the system to improve outcomes for Māori.[3] That same year, Māori postsecondary educators gathered and stated their vision for the future: *Māori* will be vibrant, educated, and successful and a significant proportion of students participating across all sectors of postsecondary education.[4]

Based on the premise that intellectual potential is not determined by racial origin (or gender), the paucity of students from Māori and Pacific Island Nation (Pasifika) peoples studying engineering represents a significant lost opportunity for both the postsecondary engineering institutions and the Māori and Pasifika communities. Thus, similar goals have also been espoused in New Zealand aspiring for participation rates that are on parity with the representation of Māori and Pasifika peoples within the New Zealand population. The issue was first identified formally in an audit of New Zealand's largest postsecondary education provider, The University of Auckland in 1998, although the focus was on improving outreach strategies rather than identifying opportunities to change the institution. Compared to the University of Auckland School of Medicine, which had introduced comprehensive programs for Māori and Pasifika students, the School of Engineering had not progressed to identifying that a problem existed. The School of Engineering was singled out for being virtually absent from all statistical measures in relation to Māori and Pasifika diversity, and the first objective of the Equal Educational Opportunities Action Plan was to develop standardized performance indicators for the postsecondary sector that all Faculties and Departments would be measured against.[5] Government funding support has since been introduced in 2003. The support is designed to enhance Māori and Pasifika student participation in all postsecondary programs and is weighted specifically towards STEM-based academic disciplines.

Literature on underrepresented minorities in engineering education has also noted persistent challenges to increasing diversity. In the U.S. context, for instance, the aforementioned NAE/ASEE-sponsored publication identified several key barriers to successful inclusion efforts:

- lack of incentives for faculty and institutions;
- inadequate or only short-term financial support;
- unsupportive institutional and faculty culture and environment;
- lack of institutional and constituent engagement;
- systemic problems in higher education, including inadequate faculty skills and K-12 engagement;
- lack of learning communities that can improve retention;
- a difficult curriculum, heavy on math; and
- inadequate assessments, metrics, and data tracking.[1]

However, this list of barriers renders the curriculum almost invisible; even though the engineering curriculum is mentioned once and may be implied in some of the above statements, the role of a curriculum that is detached from social problems that are important to underrepresented social groups is never explicitly expressed. We will return to this missing dimension at the end of this paper.

Although general inclusion issues provide a broad background, it is also important to understand specific challenges related to inclusivity initiatives designed for indigenous groups. Here we introduce the case study of the 5R Program in New Zealand.

Case Study: 5R Program at the University of Auckland in New Zealand

In New Zealand the paucity of Māori participation in engineering has been significant.[4] Aside from issues of minority underrepresentation in STEM disciplines, matters are complicated and aggravated by the historical context of Māori and Pasifika education strategies and institutional positivism that has failed to understand that students are not all the same, and that many issues creating barriers to student inclusion are outside the student's influence:

1. Historic cultural conflict between the University of Auckland School of Engineering student cohort and the Māori community, resulting in Māori students holding a negative image of engineering, a perception perpetuated by actions of the engineering profession, students, and the School of Law, as described below.
2. Historic role of the engineering profession in land confiscation and the desecration and denigration of ecosystem integrity in particular water bodies.
3. Historic exclusion of Māori from academics, as Māori were historically considered more suited to labors of the land than the mind.
4. Present-day school scheduling of subjects in ways that are culturally marginalizing, often resulting in students who are either weak in calculus or their cultural identity.
5. Institutional devaluing of identity and background, through curriculum rules regarding elective subjects.

Specific examples help to describe the nature of these five barriers.

Historic cultural conflict. An extract from *The New Zealand Book of Events* (1986) comments that on May 1, 1979, engineering students at the University of Auckland planning to perform a

mock Māori *haka* during the capping parade; these students were involved in a violent struggle with a group of Māori activists who removed students' mock Māori clothing in an attempt to prevent the "*haka* party" from taking place.[6] However, the 1979 conflict occurred after more than ten years of protests from Māori and other community groups, including the University authorities, complaining that the mock *haka* involved the use of visual and verbal profanity. The May 1 incident actually involved Māori students at the University as opposed to activists, and should have been the end of the matter, except that the families of the engineering students took legal action against the Māori students, which resulted in legal consequences in the courts and the exclusion of those students from the University of Auckland. The School of Law continued to use the case for teaching in year one until early in the new millennium.

Role of the engineering profession in land confiscation and ecosystem desecration. In Māori culture, the disposal of human effluent, particularly fecal matter and menstrual bloods, into water bodies is culturally abhorrent. These 'modern' wastewater practices along with the imposition of road lines through Māori lands and the associated destruction of forests portrayed engineering as a profession that was diametrically opposed to Māori ways of knowing and being.

Historic exclusion of Māori from academics. Despite early and widespread literacy among Māori following missionary contact—the first Māori language newspaper was published in 1842—Māori tribal schools avoided teaching Māori substantive (and elsewhere standard) academic content, preferring that Māori be educated to perform manual labor. Laws included the *Tohunga* (tribal expert) Suppression Act of 1908 and national policies that saw students caned for speaking the Māori language at school. Contemporary marginalization is more subtle but nonetheless potent, and extends to curriculum scheduling of calculus and Māori simultaneously, forcing Māori students to choose between their cultural identity and one of the essential courses required as a foundation for engineering study.[7]

School scheduling. As of 2009, in the highly prescriptive engineering curriculum, students of any ethnicity except for English are prevented from enrolling in an elective course in their ethnic language if the student has previously studied their language at school. This rule remains in place even though no other restrictions are placed on students who may have studied other subjects at school and choose them as an elective.

Institutional devaluing of cultural identity. It was therefore no surprise that Māori student enrollment in engineering at the University of Auckland was almost non-existent. Personal experience of one of the authors suggests that in the early to mid-1980s, only one or two Māori students commenced the bachelor of engineering degree each year, and it was not until 1993 that there were sufficient Māori and Pasifika students in an incoming cohort to form the support group described below. It was in this socio-cultural context that the 5R Program had its roots in the 1990s.

Engineering for Social Justice Framework

The conceptual framework for this paper centers on six engineering-for-social-justice (E4SJ) criteria. Originally designed for engineering design project evaluation and social justice integration across the engineering curriculum,[8] the E4SJ criteria are here used to help

conceptualize and analyze a recruitment, retention, and performance (RRP) initiative. Although the E4SJ criteria are being applied to this RRP program retrospectively, for reasons we explain in this paper, we encourage readers of related RRP initiatives to integrate them from the outset. The E4SJ criteria noted below are explained in more depth later in the paper:

1) *Listening contextually*
2) *Identifying structural conditions*
3) *Acknowledging political agency/mobilizing power*
4) *Increasing opportunities and resources*
5) *Decreasing risks and harms*
6) *Enhancing human capabilities*

The six E4SJ criteria add value to RRP initiatives by delineating specific yet flexible actions by which to engage previously marginalized, disenfranchised, or excluded groups and perspectives. Before exploring how E4SJ illuminates an RRP initiative, it is important to first understand the nature of various challenges associated with RRP initiatives.

Challenges to Recruitment, Retention, and Performance Initiatives

Challenges associated with RRP programs in engineering education often focus on underrepresented minorities. In the U.S., RRP programs often focus on indigenous (especially Native American Indians), African-American, Hispanic, and female students. In engineering education in New Zealand, Māori and Pasifika ethnicities and female students are underrepresented compared to their representative proportions of the New Zealand population, but that paucity of Māori students is inconsistent with historic associations with engineering.

A case in point is the *Ruapekapeka Pa* site, acknowledged in New Zealand by the engineering profession as an outstanding engineering structure that has been recognized in a national register.[9] The engineering innovation employed by Māori, while resisting the colonial forces in the New Zealand land wars, was a local response to a military strategy developed around muskets and cannons. Without access to guns and cannons, Māori resorted to structural contouring and modification of the earth to create fortifications that were highly resilient to these weapons.[10] The technologies of the Māori were sufficiently successful to be studied and exported globally in the Boer War and then World War I some twenty to fifty years later. Pasifika sail and hull technologies were similarly advanced. Despite this aptitude for engineering on land and sea, very few Māori have entered engineering education at university. This follows a trend of low participation in university generally, but with a pronounced paucity in engineering to the present day.

Historic and cultural issues associated with engineering are a problem regarding recruitment, but the greater impediment is the divergent ways of knowing. The Māori worldview holds that the ecosystem and humankind are inseparable, to the extent that Māori belong to the land;[11] such understandings are reinforced through the practiced burial of the placenta after birth, including a tree-planting ceremony. The placenta and the land carry the same name – *whenua* – as do the people - *tangata whenua* (people of this land).[12] This contrasts drastically with the scientific elevation of objectivity, based on the separation of humankind from nature. As engineering has

historically been about controlling the forces of nature for the benefit of humankind, there is an evident misalignment in the two ways of knowing and belonging. Thus, developing a sense of belonging and identity inside traditional New Zealand universities, where the dominant ideology reflects discordant ways of knowing, can be particularly difficult for Māori and other indigenous students.

Differences in ways of knowing and belonging are evident between most cultures. Of particular significance within the university setting is the emphasis of different *ways of learning, achieving, and succeeding* in postsecondary educational settings. The primary cultural difference is a focus on individual success, a component of the dominant social ideology in Western culture (individualism),[13] as opposed to the collective success, a part of the dominant ideology in Māori culture. The emphasis on theoretical foundations as the basis for understanding also diverges from indigenous methods of location, specific observation, and repetition-based learning. Engineering is as much a practical application of science as it is the intellectual application of those theoretical foundations. The method of belonging also differs in that indigenous students typically enjoy a greater sense of belonging through indebtedness as opposed to independence. That sense of indebtedness is to their ecosystem of origin and their community, as well as their cohort, teachers, and institution. Thus while learning and assessment is typically designed around individual effort in a competitive setting, many Māori can perform and achieve at higher levels wherein belonging is defined through indebtedness and achievement is a collective aspiration in which everyone is included and acknowledged.

Methods

The goal of this research is to better understand the processes by which the 5R Program at the University of Auckland reached particular levels of achievement. Our broad research question centers on *what value emerges from viewing this RRP initiative through the prism of the six E4SJ criteria*. The specific question investigates what strategies emerge from seeing the 5R Program through questions raised by the E4SJ criteria. The findings section below discusses how the 5R Program attempted to boost RRP and puts those efforts in the context of six Engineering-for-Social-Justice criteria. Below, we identify each criterion and then discuss related 5R Program efforts and outcomes.

Findings

The participation strategy addresses the ‘R’s of readiness, recruitment, retention, role modeling and research (5R), and is the basis for initiatives that have been recognized both within the University of Auckland (2003), in New Zealand (2009), and internationally (2005). It is important to understand the transformations that occurred between the late 1990s and mid-2000s and beyond. Drawing from a fairly chronological account of the 5R program evolution, we explore ways in which RRP was fostered in terms of each of the questions that emanate from the E4SJ criteria.

1) *Listening contextually*: Listening contextually contrasts with basic listening, which involves only hearing or paying attention to key actors in a communicative exchange, such as clients, customers, local community members, and others. By contrast, *contextual listening* involves a

more "multidimensional, integrated understanding of the listening process" designed to foster contextualized, cultural meanings, deeper understandings of the context of stakeholders, such as their history, culture, desires, aspirations, and forms of knowledge.[14] A question relating to this criterion to the case study is, "In what ways did the 5R Program leaders listen to the cultural, spiritual, cognitive, and other needs, interests, and aspirations of Māori engineering students when designing, refining, and improving the 5R Program?"

The 5R Program focused initial efforts on leveraging indigenous ways of knowing to succeed in an institutional and engineering context that promoted and valued diverse ways of knowing, including competition, emphasis on individual success, and nature as an object to control. By contrast, as noted above, Māori and Pasifika ways of knowing accentuate collaboration, collective effort and distribution of credit, as well as the inseparable interconnectedness of humans and nature. Thus, it was necessary at early retreats to locate at tribal gathering places and base activities around traditional protocols of cultural exchange and collective formation. Also, it was vital to listen to Māori and Pasifika students' desires, aspirations, and to honor their cultural forms of knowledge—as a prelude to strategizing ways in which the two (clearly clashing) worldviews could co-exist.

Contextual listening was enacted so Māori and Pasifika could not just survive but thrive at the University of Auckland. In academic year (AY) 1998-1999, members of South Pacific Island Engineering Students (SPIES) held retreats at the Bay of Plenty and Northland (retreats still ongoing today). Launched in 1993, SPIES' primary function was as a club and support group that signaled an indigenous presence within the School of Engineering; similar groups already existed in all other schools at the university, and SPIES provided a basis for collective belonging, via social activities and some informal mentoring. The retreat focused on building a sense of community as well as—leveraging collaborative, collective aptitudes—developing improved study skills, additional tutorials, and peer mentoring. Over time, several developments occurred organically, including the dedication of a SPIES room as a common study and gathering place—attendance records indicated daily use by 30 or more students from 2003—and engineering site visits that sought to normalize the presence of Māori in white hats on construction sites. Associated team building events and opportunities also emerged, such as sports team entries in competitions including the Engineering Rugby 7's, indoor soccer, basketball, and cultural activities including *waka ama* (outrigger canoe paddling) and performing arts, all of which students in SPIES excelled at. Indigenous E'day was created and run as a *marae*- (tribal gathering place) based event attracting 40 to 50 secondary school students from the upper half of the North Island.

2) *Identifying structural conditions*: One important outcome of listening contextually is the identification of social *structural conditions*, which constrain or enable human agency. For instance, the lack of mentors who share one's cultural traditions and history can serve as one barrier to inclusion in engineering education, as it can act as a signifier of who belongs and does not belong in engineering education.[15–18] However, structural conditions that hinder or promote inclusiveness vary for different groups, so a key case-study-related question is, "How did the contextual listening help 5R Program leaders identify the social structural conditions that blocked or facilitated Māori and Pasifika students in engineering education?

Salient structural conditions included mainstream institutional and engineering culture and ways of knowing at the University of Auckland, as well as the forced choice between studying calculus and Māori culture in high school.[7] Several initiatives were designed to counter such structural conditions. For instance, in AY 2000-2001, the Department of Civil and Environmental Engineering appointed a lecturer who provided a series of professional development lectures to Parts I to IV.[19] These lectures built an understanding of the existence of indigenous engineering knowledge and technologies, as well as shared the unique sustainability insights inherent in the history of Māori and Pasifika peoples. Also, a referential entry interview process involved SPIES' students as interviewers, establishing mentoring relationships from the first contact with engineering. Alternative pathways were established via the Faculty of Science, Manukau Institute of Technology (BEngTech) and Auckland University of Technology, contributing an additional one or two students annually. The risks of student failure were increased as a result of the preferential entry and alternative pathways, due to the less adequate preparation compared to the competitive entry process for entry into engineering, which secured the best STEM students in New Zealand. However, the support structures and strategies were effective in ensuring typically 100% retention and eventually the highest academic performing cohort at The University of Auckland, less than a decade after the program was introduced. Also, non-Māori academics started to become more involved in the support program as it realized early success, with voluntary contributions to tutorials in challenging topics and some attending SPIES' functions.

3) *Acknowledging political agency/mobilizing power*: Engineering projects and practice occur not in a vacuum but in social contexts featuring competing interests of multiple stakeholders—companies, municipalities, community members, and more. Although such competing interests are often resolved via negotiation, they also include stakeholders with diverse forms of political power to enact change. Hence, a key question becomes, "By what mechanisms did the 5R Program leaders acknowledge their own agency and the political agency of Māori and Pasifika students to address challenges and barriers, and how was such power used for creating a viable cultural space within the larger institutional context?"

The most empowering contextual reality of the 5R Program was the autonomy of the consultant initially recruited to address the poor performance of the University's School of Engineering. As a very successful consulting engineer, with a national profile and growing consulting practice, this consultant held a level of independence and resource capacity to resolve some differences of understanding; the consultant did so by simply resigning with the intention of delivering the necessary initiatives independent of the Deanery. Resignations occurred twice and lasted less than twenty-four hours on both occasions, before a satisfactory resolution of the disagreement was found. It should be noted that these barriers were typically contrived by professional staff (interestingly having emigrated from Britain) in positions of authority over assets and resources, and who typically sought to frustrate initiatives through inaction or tardiness, delaying the availability of financial resources, equipment or facilities needed for activities to take place.

The ability to acknowledge political agency and mobilize power also came from the 5R Program's growing reputation for recruiting and retaining high-performing students. In 2005, the 5R Program won a prestigious international recognition, the Australasian Association of Engineering Educators Award for Excellence in Engineering Education. Collectively, this and

other accomplishments empowered the 5R Program and provided incoming Māori and Pasifika with cultural capital from older students who served as mentors (described below). Retention continued to be a strength of the program--100%--with academic performance continuing to improve compared to the overall engineering cohort. Analysis of the 2005 Part I cohort (567 students) indicated that Māori and Pasifika students improved their comparative entry rank score by a quartile on average within their first year of study. At this stage, the capacity was present for senior Māori and Pasifika students (*tuakana*) to be meeting all tutoring requirements of their junior colleagues (*teina*), and an enthusiasm was prevalent, with *tuakana* wanting to give back what they benefitted from in their earlier years. The benefits they were now experiencing in their senior years produced an understanding of indebtedness and belonging to the collective, with the mechanism of reciprocating being the encouragement and support of their *teina*, thereby creating a self-sustaining process.

4) *Increasing opportunities and resources*: Engineers listen contextually for multiple purposes. In projects involving communities, they listen to identify structural conditions that can hinder or facilitate legitimate goals and aspirations of communities, to acknowledge the political agency of such communities, and when appropriate, to identify how the community can mobilize its own and other constituents' forms of power to achieve desired outcomes. But in terms of such outcomes, they also listen for practical reasons—to *increase opportunities and resources* that move communities or other stakeholders toward just, anticipated, and aspirational ends. In the case study context, a salient question emerges: "How did 5R leaders bolster opportunities and leverage resources for Māori and Pasifika students to surmount key inclusion challenges?"

Once contextual listening helped identify salient structural conditions and a growing reputation enabled ways to acknowledge political agency, a next step involved leveraging available opportunities and resources to promote Māori and Pasifika student success. In 2002, a Māori participation strategy was approved by Faculty, and a strategic development grant was secured to establish additional Māori and Pasifika *tuakana* positions and to fund the SPIES graduation dinner and cultural performing arts being taught to SPIES. In 2003, *tuakana* mentors and a Māori external liaison were appointed. The *tuakana* team and SPIES supported STEAM (Science, Technology, Engineering, Architecture, Medicine) and STEAM AHEAD. Given by the University of Auckland, the 2003 Inaugural Award for Excellence in Equity acknowledged SPIES' efforts. South Pacific Professional Engineers for Excellence (SPPEEx) formed in 2003 on the 10th anniversary of the creation of SPIES, and hosted research symposia. In 2004, two affirmative action scholarships were established for Māori and Pasifika students in Part I Engineering. SPIES' first Pacific retreat visited schools in Samoa and Fiji, as Pasifika students having been hosted on New Zealand *marae* for several years wanted the opportunity to host in their own traditional territories and to share the recruitment initiative in their own Pasifika nations.

The aforementioned international award in 2005 was followed by several critical opportunities. In 2006, a faculty meeting held at Fale Pasifika included the opportunity for a cultural issues workshop. The Māori artwork, *Karanga* (32' x 4'), erected in the School of Engineering foyer in conjunction with refurbishment, included a traditional blessing ceremony, affirming the place of Māori and Pasifika peoples in engineering and providing a visual touchstone for Māori and Pasifika students commencing their studies. In 2007, a faculty meeting occurred at Orakei *marae*.

SPIES' inaugural Bootcamp on Waiheke Island removed Māori and Pasifika students from the university site the weekend before the semester commenced and immersed them in a cultural experience that reinforced their cultural ties and underscored that collective success is measured through the elimination of failure: if any Māori and Pasifika person in engineering failed including academic leaders, all had failed. In 2007, inaugural SPIES member and mentee Tyrone Newson (Māori-Tongan) won the Institution of Professional Engineers New Zealand Young Engineer of the Year, raising the profile of Māori and Pasifika engineering role models. In 2008, the 5R Program launched *Kupenga Rorohiko*, which exploits evolving Internet functionality to introduce a Distance Mentoring Network for remotely located Māori secondary students considering engineering.

5) *Decreasing risks and harms*: Engineers listen not just to identify opportunities for increasing opportunities and resources, but also for *decreasing risks and harms* of multiple origins. So in the 5R Program, a crucial question is, "What steps did leaders take to confront diverse risks and harms that could jeopardize indigenous student success?"

To decrease risks and harms, particularly surrounding issues of identity and belonging in engineering, a series of professional development lectures across the curriculum and from Parts I to IV were introduced in 2000. As noted above, these lectures built an understanding of the existence of indigenous engineering knowledge and technologies among all students as well as accentuated the unique sustainability insights inherent in the indigenous ontologies of Māori and Pasifika peoples. This indigenous platform was particularly successful for introducing sustainability concepts as the conceptual underpinnings of indigenous knowledge—which are entirely consistent with the sustainability concepts now becoming increasingly common in engineering education.

Although changing student attitudes is one level of challenge, changing faculty attitudes is an entirely different level of challenge. From 2005, one Engineering Faculty meeting each year was held at a tribal gathering place to acculturate academe to the contrasting cultural context of the *marae* and Māori and Pasifika cultural norms. The rationale was that through experiencing the different but positive and supportive context of the *marae*, academics may become more open to difference and the value of indigenous perspectives and the potential contributions to curriculum and research.

Interventions were necessary at different times to respond to instances of institutional and personal racism, and micro-aggressions perpetrated by *Pākehā* (non-indigenous) academics. These issues were less of a problem with the earlier deanery, but became a problem with subsequent weaker leadership and growing envy of the 5R Program's successes.

6) *Enhancing human capabilities*: The first five E4SJ criteria ultimately serve an overarching goal: to *enhance human capabilities*. Drawing from research on the capability approach, a focus on capabilities helps make visible what is often invisible in broader economic analyses, such as gross domestic product or even local economic growth statistics.[20–23] Scholars connecting the capability approach to technological design have noted that

> According to the capability approach, a key evaluative space in these areas [justice, equality, well-being, and development] is not income, not resources, not primary goods, not utility (i.e., happiness or the sum of pains and pleasures) or preference satisfaction. Its proponents argue that the focus should rather be on human capabilities. Capabilities are often described as what people are effectively able to do and be or the positive freedoms that people have to enjoy valuable 'beings and doings.'[24]

Specifically, those positive freedoms include 10 capabilities:

1) *life* (of a normal length)
2) *bodily health*
3) *bodily integrity* (freedom from assault and the ability to move about freely, etc.)
4) *senses, imagination, and thought* (which are critical to being fully human)
5) *emotions* (love, grief, longing, gratitude, and more)
6) *practical reason* (for critical thinking, freedom of conscience, etc.)
7) *affiliation* (including protecting institutions that advance compassion and ensuring the social preconditions for self-respect and non-humiliation regardless of sex, ethnicity, sexual orientation, etc.)
8) *other species* (how we manifest respect for plants, animals, and nature in general),
9) *play* (recreation, laughter), and
10) *control over one's political and material environment.*[20–22]

Ultimately, how did 5R programmatic actions augment select student capabilities and contribute to their high levels of academic achievement?

Overall, the 5R Program was built around the existing support structure, SPIES. The gradual evolution of the approach was necessary as the initial cohort of students had created their own ways of knowing and belonging, which were not very well aligned with Māori cultural values, so much as performing to the expected stereotypes of others.

In particular, *Affiliation* (capability 7 above) was a critical freedom that underpinned the success realized by the SPIES cohort. The 5R programmatic actions were all required to strengthen the sense of belonging of students and their sense of legitimate place in engineering, and the place and potential contribution of engineering knowledge within their communities of origin. The relevance of engineering knowledge within these students' ecosystems of origin (8 and 10) was also an important consideration to ensure that students were not as vulnerable to being indoctrinated into ways of knowing that were antithetical to their cultural identity and beliefs. Finally, and indirectly linked to some capabilities (esp. 3-6, 9) it was important to cultivate a positive SPIES' identity that was associated with excelling in all spheres of activity as well as a positive overall experience of university to counter the undermining negative stereotypes held by society, other students, and academics.

Discussion

New insights emerge from seeing the 5R Program through the prism of E4SJ. Even though the E4SJ criteria were not used at the outset of program development in the 5R case, they can be

used after a program has been in place for some time as a calibrating tool (or corrective mechanism); such application of E4SJ criteria can put a program that did not have explicit commitments to social justice in line with researched social justice principles. Even though initiatives similar to 5R emerge in different national contexts for different reasons and face diverse structural conditions, assessing them through E4SJ criteria can serve as a mechanism to establish their effectiveness in relationship to social justice outcomes. Most diversity programs are evaluated in terms of students recruited and retained, their academic achievement, or their self-efficacy. While these parameters are important, they do not tell us much about whether and how a program enhances overall social justice for a particular demographic group. Evaluating programs through the prism of E4SJ is an important step in that direction.

While there is a potential for negative stereotyping to be associated with affirmative action programs, the experience of SPIES was quite the opposite. Before 1998, SPIES had to a large degree conformed to these negative stereotypes, even though no preferential entry program existed, which ensured that their reputation among the broader campus community involved consuming copious quantities of alcohol and academic achievement that reflected barely passing grades. There was an attitude that anything better than a C grade reflected poor judgment in that too much effort had been given to that particular subject, instead of the wider experience that the university offered. After 1998, however, once the 5R Program leader engaged in extensive role modeling (including playing sevens rugby, paddling outrigger canoes, leading the war dance, running tutorials, and much more), he achieved the kind of status and respect among Māori and Pasifika students that allowed the challenge to the cohort—that it could instead excel in other ways—to resonate. A stronger commitment to excellence, including academic, emerged, and this was possible through a collective (not individualistic) approach. From there the strategy involved the progressive development of an identity that emphasized excellence in all forms, both extra-curricular and academic. The success of this approach was such that by 2004 SPIES was considered to be the "coolest" club in engineering, winning every sporting competition, and eventually also excelling academically. In 2009, a Samoan student graduated first class division I in both mechatronic engineering and law degrees; this accomplishment had never been achieved previously in the history of the university (and has not been replicated since).

For RRP programs, this research has implications for not just Māori and Pasifika students but for indigenous groups more broadly. All the authors of this paper have heard diversity initiatives critiqued as being primarily good public relations for engineering schools, serving the school more than they actually serve students. Some faculty and students at our institutions cast RRP initiatives as forms of reverse discrimination, which they see as reaching for some imagined quota of students who privileged and/or mainstream students may depict as less deserving.[25] But by using the E4SJ framework, the focus goes back to serving the indigenous students and building their capacities by *honoring their social and cultural groups and origins*. Specifically, the E4SJ framework can empower indigenous groups as it gives them criteria to hold 5R initiatives accountable: it gives them the language of what to aspire to and ask for in a welcoming, effective 5R program.

Yet the research also has broader implications for RRP that serve all underrepresented minority groups in engineering education. The E4SJ criteria will allow RRP administrators who are

committed to a transformative, social justice framework to go beyond just doing "good PR" for their schools and shift the programs focus on SJ to transform the overall student experience.

Viewing the 5R Program through the prism of the E4SJ criteria also unveils something critical about this RRP program: it highlights the importance of acknowledging underrepresented students' culture and values not just *outside* the engineering curriculum, but *within* it. In different ways, the 5R Program accentuates that a curriculum that is detached from social problems that are important to underrepresented social groups is a missed opportunity. Sustainability is part of the rich cultural history of Māori and Pasifika people, and their engineering feats—from *Ruapekapeka Pa* to Pasifika sail and hull technologies and more—provide a cultural context in which ancestral engineering excellence is showcased. By making these accomplishments visible *in the curriculum* and as part of the SPIES and related 5R Program initiatives, Māori and Pasifika engineering students gained appreciation for ways to use technology to also solve contemporary problems that persist in (and beyond) their home cultures.

Several issues from the aforementioned NAE/ASEE workshop[1] emerged as prominent in this case study:

- unsupportive institutional and faculty culture and environment;
- lack of institutional and constituent engagement;
- systemic problems in higher education, including inadequate faculty skills and K-12 engagement;
- lack of learning communities that can improve retention;

To address longstanding unsupportive institutional culture, in 2009 one of the co-authors, Associate Dean Māori, delivered the Dean's lecture, *He Taua*. The significance of this event was the role that it played in resolving the long-standing historical *hara* (violation or harm) inflicted on Māori by the engineering students' 1979 belittling of the iconic *haka* and the subsequent arrest of Māori University of Auckland students. Following the lecture, the Associate Dean Māori led SPIES performing a redemption *haka* suited to the occasion with the effect of contributing to the righting of a serious wrong. In the audience that day were the Māori students who were arrested in 1979.

Addressing the lack of institutional and constituent engagement emerged from programmatic excellence. As noted above, in 2009 the New Zealand Universities Academic Audit Unit *commended the effective impact of the Faculty of Engineering equity strategy*, acknowledging the achievement of 100% Māori retention from Parts I to III of the Bachelor of Engineering program and the very high pass rates in 2009.[26] Under the 5R Program's leader, from 2003 to 2010, the Māori student pass rate steadily increased from 89.8% (vs. 94.4% for all students) to 94.9% and the proportion of 'A's has continuously increased from 15% (2003) to 33.5% in 2010. These significant outcomes were recognized with an Excellence in Equity award in 2012.

To combat systemic problems in higher education, including inadequate faculty skills and K-12 engagement, the 5R Program leader and Associate Dean Māori engaged in a multipronged approach. For instance, engineering students serve as interviewers of prospective secondary

students and later mentored them. Also, the *marae* event attracted secondary school students from the upper half of the North Island and at times engineering faculty were included in *marae.*

The lack of learning communities that can improve retention was a major focus of the 5R Program. The 5R Program leader and Associate Dean Māori has always been a strong advocate for SPIES, securing opportunities that have contributed to success of the Māori and Pasifika student cohort as a collective using the *Tuakana Teina* philosophy he introduced in 1998. The *Tuakana Teina* approach follows the pattern of senior mentoring junior, similar to a cascade with the more experienced active academic mentoring and advising the senior student cohort, who then share the responsibility for mentoring the junior student cohort.

The transformation of the engineering experience for Māori and Pasifika students began in 1998 and progressed through 2009, when the New Zealand Universities Academic Audit Unit commended "the effective impact of the Faculty of Engineering equity strategies."[26] The initiatives developed over that decade and the successful implementation of the 2002 Māori participation strategy speak to the unrealized potential of reinforced student indigeneity and the collective indigenous identity that Māori and Pasifika students contribute to the University of Auckland. The initiatives have evolved organically within the initial broad aspirations set by the 2002 Faculty of Engineering strategy.[27] The 5R Program approach and related efforts culminated in significant milestones in 2009 and 2010. Māori student pass rates exceeded 94% and retention from part I to part III was a perfect 100%. Recent changes in focus have not echoed the positive trends experienced up to 2010. It is hoped that the exemplary outcomes of the previous strategy will be noted and the opportunity taken to reinstate proven, previously adopted initiatives.

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