Ha'otā: Transforming science education in Aotearoa New Zealand for Tongan students

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Tauhi etau vā

In late 2000, several prominent Pacific scholars developed *Rethinking Pacific Education Initiative for and by Pacific People* (RPEIPP) to "re-conceptualise education...that would allow Pacific peoples to reclaim the education process" (Taufeu'ulungaki, 2014, p. 5). Since then, the RPEIPP space has enabled Pacific scholars to consider how their positioning, cultural values and knowledge inform their practice. I was privileged to be invited to articulate my positioning in respect to RPEIPP at the 2018 Vaka Pasifika conference in the form of a poem. *Tauhi etau vā* is that poem which I dedicate, alongside this thesis, to my children who have taught me more than anything or anyone.

Pāpālangi, white eyes
Awakened to my fatongia
Mother of Tongan boys
Challenges my white eyes always.
Confronted by the intimacy of tauhi vā
Honoured to nurture our ties

Seeking to disrupt and decolonise
Questions often asked from white eyes,
White ears and white minds
Raising intimate questions like:
Is Tongan knowledge really science?
Do Tongans even have science?

Through brown eyes
I see beauty, I see success
Through white eyes
I am expected to see failure, to see loss
I hear the calling of fish in Ha'ano
My husband's genealogical ties to Ha'apai

Seeing you both through coloured eyes
My duty, my obligation,
My service as a fa'e to
My beautiful sons
Be who you choose to be
Be proud and strong of your ancestral ways

Decolonised white eyes
Seeing through strength
To thrive and survive
Tongan ways and my Tongan sons
Makes more sense
Through coloured eyes, I see, finally.

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Abstract

Enhancing the education outcomes for Pasifika[1] learners has been a priority focus of Aotearoa's education policy for several decades, yet for many Pasifika science learners very little has changed. At the same time, while there is some evidence how to engage Indigenous science learners, including Pasifika, little is known about how to specifically engage Tongan science learners to improve their educational outcomes and enhance their teaching and learning experience. Influenced by a combination of Tongan, Pacific[2] and mainstream qualitative research methodologies and frameworks, the stories of 26 successful Tongan science learners were collected and analysed regarding enjoyment, engagement, success and pedagogical practice in their secondary school and university science education experiences. Their stories have driven the development of a pedagogical framework for science educators to use which considers and locates factors contributing to Tongan science learner success. Ultimately this may be used by educators and policymakers to address concerns around retention of Tongan (and other Pasifika) students in science, particularly how education policy and practice can address the underachievement of Tongan (and other Pasifika) students.

Drawing on Bhaksar's critical realism (1978), relationality in the form of *vā,* Ogawa's (1995) Multiscience Framework, and several Tongan and Pacific methodologies as theoretical frameworks, this research engages in a critique of the valuing of relationships in western modern science education, and formal educational institutions and mainstream culture in general. It uses Epeli Hau'ofa's (1993) seminal essay 'Sea of Islands', and the articles of support and critique found in 'A New Oceania' (1993) to employ Oceania as the context, connector and source for the participants' stories. The findings not only challenge assumptions about the neutrality of the learner experience in secondary and university science education, they also identify the deficit views of the Pasifika science learner identity (both externally and internally). The findings also highlight the resilience Pasifika science learners must display to succeed in Aotearoa and the predominantly negative outsider perceptions of the 'Tongan Education Experience' in Tonga. This research proposes that remembering our humanness and the importance of social connectedness, readily visible in Tongan and other Pasifika cultures through the emphasis on *tauhi vā* (maintaining of the relational space), would improve the educational outcomes for all science learners regardless of ethnicity. This thesis also explores perceptions of Indigenous science knowledge and Tongan science knowledge and its presence in formal education in Tonga and Aotearoa and the impact of westernisation on the valuing of Tongan science knowledge. The findings argue that the inclusion of Tongan science knowledge in formal education acknowledges its

[1] A system of categorising commonly used in education that considers individuals of Pacific Island ancestry who live in Aotearoa, including Tongans, as one group.

[2] Pacific refers to the islands of the Pacific Ocean, including Tonga.

existence and value and creates the opportunity for positive impacts on wider factors such as learner identity, especially for Tongans raised and educated in Aotearoa New Zealand.

Abbreviations

ANZE	Aotearoa New Zealand Educated
I(S)K	Indigenous (science) knowledge
KOTE	Kingdom of Tonga Educated
KRF	*Kakala* Research Framework
MSF	Multiscience Framework
NCEA	National Certificate of Educational Certificate
NZQA	New Zealand Qualifications Authority
NZC (2007)	New Zealand Curriculum (2007)
PEP	Pasifika Education Plan(s)
PISA	Programme for International Student Assessment
RPEIPP	Rethinking Pacific Education Initiative for and by Pacific People
TES	Tertiary Engagement Strategy
TIMSS	Trends in International Mathematics and Science Study
TS(K)	Tongan science (knowledge)
UE	University entrance
USP	The University of the South Pacific
WMS(K)	Western modern science knowledge

Chapter One: Introducing the research and the researcher

This chapter gives an overview of the Tongan population in Aotearoa New Zealand[3], including their educational experiences and location within the term 'Pasifika'. It introduces the two contexts and educations systems where the research participants have been or currently are located, Tonga and Aotearoa New Zealand. I also explain my positionality: firstly, as an 'insider' tertiary science educator; secondly, an 'outsider' non-Indigenous science educator and researcher; and thirdly, an 'external insider' member of a Tongan family residing in Aotearoa New Zealand. The research problem is then outlined and its significance explained concerning the impact, importance, and interplay of Tongan science learners in Aotearoa New Zealand.

Overall aim and purpose of the research

Konai Helu Thaman is a prestigious Tongan academic and poet. One of her poems entitled 'Our Way', published in 1987, is useful here:

OUR WAY

your way
objective
analytic
always doubting
the truth
until proof comes
slowly
and it hurts

my way
subjective
gut-feeling like
always sure of the truth
the proof
is there
waiting
and it hurts

[3] Aotearoa is the Māori (Indigenous) name for New Zealand. It translates as 'the land of the long white cloud'. I use both the Indigenous name and the colonised name in this research to acknowledge the original people of the land and their history, as well as the name by which the country is known internationally.

This poem eloquently positions two forms of knowing, 'your way' and 'my way', to highlight their differences. For me, it contrasts western modern science (WMS) knowledge as 'your way' and Indigenous science knowledge (ISK) as 'my way', speaking to the boundary Indigenous science learners must often cross to be able to be successful in their academic pursuits in western institutions.

As WMS is the foundation of most formal science curriculums globally, the 'learning gap' created by the conflict of Indigenous and western value systems (Little, 1990) has contributed to the underachievement of Indigenous science learners in many contexts. This issue is particularly true where there is no inclusion of Indigenous science in the formal science curriculum (Howlett, Seini, Matthews, Dillon & Hauser, 2008). In Aotearoa New Zealand, despite education policy reforms attempting to make the curriculum inclusive of Pasifika culture, non-western knowledge is not often acknowledged in secondary school or university. Thaman (2003) has long argued for its recognition and inclusion, particularly at the university-level, because of the contribution Indigenous knowledge can make to the curriculum as well as the benefits it can offer to students, their institution, and broader society.

Over a decade and a half ago, Nakhid (2003) highlighted the continued absence of Pasifika pedagogy, deficit perspectives on who Pasifika students are, and the negative influence of their Pasifika values on their Pasifika student achievement. Concerns around the mismatch between the cultures of education systems and Pacific learners and how that influenced the experiences of Pacific learners, as well as the need to include Pacific languages and knowledge into the curriculum and considerations around pedagogy, had been raised previously (Coxon, Anae, Mara, Wendt-Samu & Finau, 2002). More vocalising of these issues over the next few years (for example, Alton-Lee, 2003; Manu'atu, 2009) resulted in some improved engagement in enabling pedagogical practices but there was still evidence that teachers' actions were impacting negatively on Pasifika achievement (Ferguson, Gorinski, Samu & Mara, 2008).

As discussed in Chapter One, government policies such as the various Pasifika Education Plans (PEPs) continue to focus on the need to improve Pacific education outcomes. There does seem to be some shifts in achievement, such statistical indications that more

Pasifika students are gaining the secondary school qualifications required to progress into tertiary education. However, contemporary calls from the Pacific to decolonise and disrupt western systems or practice in the Pacific mirror similar efforts in Aotearoa New Zealand, highlighting the need for Indigenous peoples to engage in "active theorising" (Koya-Vaka'uta, 2016, p. 20) and for "interrogation from and based on each of our own knowledge systems" (Fa'avae, 2019, p. 5).

In response to such calls, this research is attempting to disrupt and decolonise science education using the voices of successful Tongan science learners and my critical self-reflexive practice, stories that detail the importance of understanding each other's values, cultures, and knowledges in science education. It also explores the engagement, enjoyment, and achievement of university-level successful Tongan science learners to identify which teaching and learning approaches and environments could foster achievement for all Tongan students.

I am interested in the role that ISK had applied in the academic journey of these successful Tongan science learners. This research contributes a new narrative about Tongan (and Pasifika) achievement and success, and an emphasis on the need to value ISK. The proposed lens, Fakahila, provides science educators with a framework to consider their critical self-reflection regarding teaching and learning and is discussed in Chapter Ten.

The research questions

As stated previously, an increasing proportion of all school students, particularly in Auckland, are Pasifika students. There are also more Pacific tertiary students, representing a demographic shift for the tertiary sector, compounded by a concentration of Pasifika learners in Auckland's universities (Education Counts, 2018a). This change is an incentive to address teaching practices and learning environments so that they do not continue to hinder the successful engagement, enjoyment, and success of many Pasifika students (Benseman et al., 2006; Airini et al., 2010). There are also often issues of retention during and beyond their first year of study (Statistics New Zealand & Ministry of Pacific Island Affairs, 2010; Middleton, 2008), particularly for universities, as Pasifika students are less likely to complete a diploma or degree-level qualification than other groups (Earle, 2018).

It is vital to determine, from Pasifika themselves, in this case, Tongan science learners, what it is that promotes their engagement, enjoyment, and success in their science studies.

This understanding will give educators a better comprehension of how to engage Pasifika science learners so that they may be successful in the Aotearoa New Zealand education system (Statistics New Zealand & Ministry of Pacific Island Affairs, 2010) and/or engage as active citizens in their communities (Gluckman, 2011).

The research questions developed for this study explore the experience of successful Tongan science learners in the following ways:

RQ1.

How do successful Tongan science learners define engagement, enjoyment, and success?

> This question explores the way these learners consider, value, and rank engagement, enjoyment, and success regarding their learning and achievement in science.

RQ2.

What does 'science' mean for a Tongan science learner? What are Tongan science learners' perspectives of Indigenous (Tongan) science knowledge?

> These questions explore their knowledge, values, understanding, and attitudes toward Indigenous science.

RQ3.

Which teaching and learning practices encourage engagement, enjoyment, and success in science for Tongan science learners?

> This question seeks to identify tangible examples of positive and negatives experiences that will provide educators with guidance as to how to make their teaching and learning spaces more appropriate for Tongan science learners.

Situating Pasifika people in Aotearoa New Zealand

Pacific communities in Aotearoa New Zealand are diverse, vibrant, and well-established. Their members can range from recent migrants from Pacific nations to third- or fourth-generation Aotearoa New Zealanders with Pacific heritage (Pasifika Futures, 2017). Several countries, including Samoa, Tonga, Fiji, the Cook Islands, Niue, and Tokelau, have long

political and legislative ties with Aotearoa New Zealand; the Cook Islands, Niue, and Tokelau have citizenship rights, while others do not.

Since the mid1940s, there has been a considerable increase in the size of the Pacific community in Aotearoa New Zealand, rising from a population of 2,200 in 1945 (Statistics New Zealand & Ministry of Pacific Island Affairs, 2010) to 381,642 in 2018 (Statistics New Zealand, 2019c). Although the initial growth was slow, the number of migrants from Pacific nations accelerated in the 1960s to make Pacific people 2.1% (or 65,700) of the total Aotearoa New Zealand population by 1976. Labour demands in Aotearoa New Zealand primarily drove this increase aided by various Aotearoa New Zealand government policies. These policies included quota schemes (for example, the Western Samoan Quota scheme begun in 1962, and the Pacific Access category established in 2002), family reunification policies and temporary permits which enabled migrants from places such as Samoa, Tonga and Fiji, to settle in Aotearoa New Zealand more easily (Statistics New Zealand & Ministry of Pacific Island Affairs, 2010).

Economic changes in the mid1970s meant these previously flexible policies became increasingly restrictive. Despite this, the Pacific population has continued to proliferate, making up 8.1% of the total population at the time of the 2018 Census. Statistics New Zealand (2010) estimated that 17.7% of children in Aotearoa New Zealand in 2026 would be Pasifika, up from 12.4% in 2006. According to Pasifika Futures (2017), the growth rate of the Pacific population is twice the rate of the overall Aotearoa New Zealand population, and 69% of Pacific families have at least one child under 18 years of age. The New Zealand Deprivation Index, which measures nine socioeconomic variables including household income, education, and employment, demonstrates that Pacific people are less advantaged than other ethnicities in Aotearoa New Zealand (Pasifika Futures, 2017).

In 2018, Pacific people were the third largest ethnic minority category, most lived in the Auckland region (63.9%) and 62.3% were born in Aotearoa New Zealand (Statistics New Zealand, 2019a; 2019c). It is a fast-growing and youthful population: Pacific people have the highest proportion (35.7%) of children under 15 years of age compared to 19.6% of Pākehā, 33.8% of Māori and 20.6% of Asian. Furthermore, 46.1% of the Pacific population were less than 20 years old compared with 27.4% of the total population, and 54.9% were younger

than 25 years old (Statistics New Zealand, 2019b). Predominantly concentrated in the Auckland region, particularly South Auckland, Pacific peoples are also an increasing presence in other areas of Aotearoa New Zealand; for example, 12.2% live in the Wellington region.

Situating Tongans in Aotearoa New Zealand.

According to the 2018 Census, Tongans were the second-largest Pacific ethnic group: 21.6% or 82,389 people identified as Tongan compared to 47.8% (or 182,721) Samoan and 21.1% (or 80,532) Cook Islands Māori (Statistics New Zealand, 2019d). Age-wise, 42% of Tongans were aged under 15 years old, and the median age was 18.6 years old (Statistics New Zealand, 2008[4]). Despite Samoan being the largest Pacific ethnicity, Tongans are the fastest growing Pacific population, primarily because of natural population growth: Tongans experienced 19.5 percent growth for 2006-13 compared with 9.9 percent for Samoans (Statistics New Zealand, 2019b). The young age of the Tongan population also makes them an increasing presence in Aotearoa New Zealand's schools (both primary and secondary), making up 3.8% of the total student population in 1998 and 5.5% in 2018 (Education Counts, 2018b).

Using 'Pasifika' vs. 'Pacific peoples'.

Currently, 'Pasifika' is commonly used in the field of education to describe the Pacific diaspora in Aotearoa New Zealand (Ministry of Education, 2009), as opposed to the term 'Pacific', which signifies the island nations of the Pacific excluding Australia and Aotearoa New Zealand. The Ministry of Education defines Pasifika as "a collective term used to refer to people of Pacific heritage or ancestry who have migrated or been born in Aotearoa New Zealand" (Ministry of Education, 2009a, p. 3).

Although the term to identify or refer to people from the Pacific has changed over time, using a single term has been contested for homogenising the experience of Pacific people, often depicting aspects of the larger Pacific migrant populations' cultures and experiences as universal. For several decades, using a collective term has been argued by several researchers to "conceal[s] and undermine[s] the historical social, political and cultural uniqueness of each Pacific Islands society" (Mara, Foliaki & Coxon, 1994, p. 182). Although the 'Pasifika Umbrella' term (Samu, 2015) includes the islands groupings of Melanesia,

[4] The 2018 census data was not available to this level of detail by the submission date.

Micronesia, and Polynesia, in Aotearoa New Zealand, it primarily refers to people with ancestry from six island nations: Samoa, Tonga, the Cook Islands, Niue, Tokelau, and Tuvalu. Because these are island nations located within Polynesia, 'Pasifika' often ends up referring only to Polynesian peoples (Anae, Coxon, Mara, Wendt-Samu, & Finau, 2001). Inevitably, this contributes to the idea of homogeneity within Pacific people, with some, such as Anae (Perrot, 2007, p. 25), quoted as saying Pasifika is "a label of convenience, a new administrative stereotype that enables different Pacific cultures to be lumped within one easily tickable box".

Other researchers have raised concerns that Pasifika can often act as a placeholder for Samoan because of the size of the Samoan population in Aotearoa New Zealand. For example, Māhina argued,

> [I]t's becoming a reality that whenever something is considered Pasifika, in reality it is Samoan, and by being seen as Pasifika, we are being seen as Samoan. So, there is some antagonism, because we all hold different views, we all have different histories, we have different cultures, and we speak different languages (cited in Perrot, 2007, p. 31).

Despite the criticisms of Pasifika, it remains a useful term in this thesis for two key reasons: it is well-used in Aotearoa New Zealand's education policy and initiatives; and it distinguishes between Pacific peoples located in Aotearoa New Zealand and Pacific peoples located in the broader Pacific region, specifically Tonga. Therefore, in this thesis, as per Burnett (2012), Pasifika is used to indicate either people with ancestry to island nations of the Pacific region who live in Aotearoa New Zealand, or research about them. The term Pacific will be used to signify either people who reside in island countries of the Pacific or research about them[5]. Although the primary focus of this thesis is on successful Tongan science learners resident in Aotearoa New Zealand, it also aims to counter the deficit narrative around Pasifika learners generally, and the propensity of educators and researchers to homogenise ethnic populations. Accordingly, there are instances where the findings have been broadened to include other Pasifika learners, and, on rare occasions, Pacific learners. The intention of this is to emphasise the specificity of the research to Tongan science

[5] The New Zealand census ethnicity categories are used in this thesis where appropriate. For example, the term 'Pacific peoples' is used in the census to collect data on any person who identifies as having Pacific ancestry and does not differentiate into Pasifika or Pacific the way that other government organisations do.

learners while maintaining the possibility that some findings may be useful to consider for the broader group of learners who have Pacific heritage and reside in Aotearoa New Zealand, and for those who live and study in the broader Pacific region.

Situating Pasifika people in education

Pasifika students are a priority focus for many of Aotearoa New Zealand's education policies because, for a long time, the achievement of Pasifika students has been consistently lower than for other ethnic groups. This focus is necessary because, although the size of the Pacific population is smaller than other migrant groups, their level of underachievement and their concentration in Auckland means it is perceived that the success or failure of the Pacific population has consequences for Aotearoa New Zealand. The Ministry of Education has projected that "by 2051, one in five children will be a Pacific child… [which] provides a sense of urgency to ensure the educational needs of Pasifika children are met across all three sectors" (cited in Samu, Mara & Siteine, 2008, p. 148).

Pasifika students' secondary school results have historically been quite different from the general Aotearoa New Zealand pattern: "Pasifika in the secondary school system achieve only to low levels and few achieve the required standards for entry into conventional tertiary programmes" (Middleton, 2008, p. 11). These disparities have driven the development of Pasifika specific policies, such as the Ministry of Education's Pasifika Education Plans (PEP), to address the situation across all levels of the education system as "students most at risk of not succeeding are Pacific" (Education Review Office, 2012, p. 4).

In 2012, the Education Review Office released a report that indicated that despite a government focus on Pacific achievement there had been very little shift in the results achieved up until then. The report suggested this was because of limited adoption of these policies in parts of the education system. Since the release of the PEP 2012-2017[6], the first PEP with a statement of support signed by various government organisations, monitoring reports have noted that shifts have been occurring; for example, there is evidence of an increase in the number of Year 11 Pasifika achieving National Certificate of Educational Achievement (NCEA) Level 1 (64.8% in 2013 to 73.3% in 2017), Excellence Endorsement in NCEA Level 1 (4.7% in 2013 to 7.3% in 2017) and Excellence Endorsement in NCEA Level 3

[6] Extended to 2018 by the Labour government.

(2.4% in 2013 to 4.2% in 2017) (New Zealand Qualifications Authority, 2018). Although these numbers provide evidence that change has happened, this change is not fast enough; the achievement of Pākehā[7] students has also increased (12.7% to 18.1%) during the same timeframe and is still more than four times higher for Excellence Endorsement NCEA Level 3 than Pasifika students (New Zealand Qualifications Authority, 2018). Concerningly, this suggests that despite governments' targeted focus to address Pasifika academic outcomes, Pasifika learners are still not experiencing the same academic success as other students.

The number of Pasifika students leaving secondary school with Level 3 NCEA doubled from 23.2% in 2009 to 46.4% in 2017 (Education Counts, 2018c). Furthermore, 58% of Pacific students attained NCEA Level 3 in 2015 (Pasifika Futures, 2017). Although an improvement, there are still issues around Pasifika completion rates at university and the over-representation of Pasifika students in lower-level tertiary certificates rather than university-level courses (Ministry of Social Development, 2016). Only 30% of Year 13 Pacific students attained University Entrance in 2015 compared with 57% of Pākehā, 65% Asian, and 31% Māori (Pasifika Futures, 2017). According to Earle (2018), Pasifika students are less likely to complete their bachelor's qualification and less likely to complete most of their first-year courses: fewer than 60% of Pasifika students complete 85% of their first-year courses compared with over 80% of Pākehā students. Interestingly, the higher achievement for females seen in all other ethnic groups was not evident in Pasifika students.

In 2008, Middleton discussed the impact of inappropriate and inequitable academic preparation on Pasifika student advancement in each level of the education system and concerns around completion and retention rates. Seven years later, despite Pasifika students completing more than twice the number of tertiary qualifications in 2014 than they did in 2007, the completion rate (74%) was still lower than for Māori (77%), Asian (86%) and Pākehā (86%) (Ministry of Education, 2016). Importantly, while Pacific peoples are an increasing presence in bachelor's level study: 9.5% of full-time students in 2017 were Pacific compared with 6% in 2008, the Pacific population in Aotearoa New Zealand has the lowest proportion of people holding a bachelor's degree or higher (5.4% in 2005; 8.6% in 2015) (Ministry of Education, 2016). All this contextual information indicates that previously identified issues

[7] Pākehā, in *te reo* or the Indigenous language of Aotearoa New Zealand, refers to an individual of European ancestry.

around retention, completion, and achievement for Pasifika (for example, Benseman et al., 2006) are still current despite several decades of government focus on Pasifika achievement. If previous educational success does indicate tertiary education success, the improving academic position for Pasifika school leavers is not translating to an improved tertiary experience. If inappropriate and inequitable academic preparation is hindering Pasifika student advancement, it may be possible to infer that their secondary school experience is also an issue. At the same time, what might be translating across these two spaces is institutionalised racism and educational processes that privilege non-Pasifika values and experiences.

Situating Pasifika people in science education

Turner, Irving, Li, and Yuan (2010) found that Pasifika students attempt fewer NCEA Level 3 standards on average than Pākehā and Asian students. They also suggest that Pasifika students are taking fewer mathematics and science courses. Yet, there is minimal data publicly available on the number of Pasifika students who study science or succeed in science subjects at either secondary school or tertiary institutions. One data source that is available is the Programme for International Student Assessment (PISA).

Regardless of the debate about the value of global tests such as PISA, considering the results in this research is useful because of the lack of national data and because they indicate that ethnic disparities exist. For example, overall, Aotearoa New Zealand performed reasonably well; in PISA2015[8] Aotearoa New Zealand ranked 10th equal with Slovenia (out of 35) for student performance in science[9] (Organisation for Economic Co-operation & Development, 2018). However, the data also indicate there is considerable disparity within Aotearoa New Zealand secondary students' performances, and ethnicity influences achievement in science: both Pākehā and Asian students have higher average scores than Māori and Pasifika students (Bull, Gilbert, Barwick, Hipkins & Baker, 2010, p. 19,20). Furthermore, the PISA2015 test found that Aotearoa New Zealand has one of the lowest levels of equity in science learning outcomes,

8 In 2009, New Zealand was ranked 5th (out of 34) for student performance for reading, mathematics and science performance (Telford & May, 2010). The 2015 data set was used in this thesis because it was closer to the time the participants were in secondary school.

9 "measures the scientific literacy of a 15-year-old in the use of scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues" https://data.oecd.org/pisa/science-performance-pisa.htm

and Pacific students have the worst attainment by ethnicity (May with Flockton & Kirkham, 2016).

The connection between ethnicity and science continues at university. Just under 50% of Pacific students are passing 85% of their first-year courses in a bachelor's degree in a field of science compared with almost 70% of all students (Ministry of Education, 2018). Despite the perception that science has higher levels of difficulty and expectation than other fields of study, such as education and health, this situation raises concerns about what is happening during the educational experience of Pacific science learners in their bachelor's studies.

Bull et al. (2010) suggest that to determine how to define achievement in science, we must first identify the purpose of Aotearoa New Zealand's science education. They suggested that if the intent of science education is for 'pre-professional training', Aotearoa New Zealand's top secondary school students perform very highly according to international measures which means the system is successful. However, if the purpose is for citizenship and the ability to participate in meaningful social debates, then most Aotearoa New Zealand's students should be achieving well, not only a small proportion. The PISA results and data about bachelor's level study for Pasifika students outlined above reinforces the urgency and need to understand the teaching and learning approaches and develop initiatives that may address the ethnic disparity of achievement, particularly for Pasifika science learners.

Situating Tongan learners in science education

Pasifika have world views and perspectives which differ to those presented in the mainstream education system. These world views and perspectives may not fit with the current teaching and learning methods driven by recent reform and globalisation[10] processes. Furthermore, although Pacific island peoples may share some widespread beliefs and values (Hau'ofa, 1998), Pasifika peoples are not homogenous. There is considerable variation in ideologies and viewpoints between the different Pacific ethnic groups in Aotearoa New Zealand (Samu et al., 2008). As previously stated, a single label masks the complexity of each group hence the need to begin focusing on individual ethnic groups to meet their specific needs.

[10] The globalisation effects on education are *"largely a product of that financially-driven, free market ideology, not a clear conception for improving education"* (Carnoy, 1998, p. 28, cited in Vidovich & Slee, 2001).

The PEPs indicate that educational achievement for Pacific students is a government priority, yet Pasifika students, despite recent improvements, have some of the lowest achievement rates in Aotearoa New Zealand. Furthermore, the homogenising approach to policies for Pacific education in Aotearoa New Zealand does not acknowledge the cultural nuances of Pacific groups. Vaioleti (2011) argued that if "an acknowledgement of [their] Tongan identity and the knowledge that their unique ways of learning and current knowing are respected", Tongan student achievement will improve at all levels of the education system (p. 13). A lot of research has focused on Pacific students, particularly relative to other ethnic groups (i.e., Pākehā, Māori), but there is limited research specifically focused on the experiences of Tongan students in Aotearoa New Zealand. Thus, this research focuses on Tongan science learners. Nevertheless, it is likely that the findings of this research will also improve science educators understanding of how to engage all Pasifika science learners so that they may be successful in Aotearoa New Zealand's education system.

The research problem: Impact, importance and interplay

Pasifika students have been a key concern, or targeted learning group, for education in Aotearoa New Zealand for several decades (Ministry of Education & the Ministry of Business, Innovation and Employment, 2014). However, despite this focus, there is still considerable opportunity to improve Pasifika achievement in the education system and offer ways to counter the often overly deficit views of Pasifika education. Therefore, this research proposes considering this situation in three ways: firstly, acknowledging the impact of Pasifika achievement in science education; secondly, the importance of acknowledging and valuing Indigenous (science) knowledges for engagement, enjoyment, and success; and thirdly, recognising the interplay between cultural diversity, pedagogy and curriculum for engagement, enjoyment, and success in science education.

'Impact' refers to the effect of an education system that does not enable Pasifika achievement to be on par with other ethnicities. A lack of appropriate and equitable academic preparation for students hinders their successful advancement, engagement, and participation at each successive level of the Aotearoa New Zealand education system (Middleton, 2008). If the Pasifika student success rates are not improved, not only does this negatively impact the Pacific population, but it also potentially adversely affects Aotearoa

New Zealand's economic development (Samu et al., 2008). Furthermore, the projected demographic shift caused by the increasing Pasifika population demands an increase in understanding how to engage Pasifika students in science education.

'Importance' recognises the need for Pasifika achievement in education and particularly within science. It also argues for the need to value, acknowledge, and respect Indigenous knowledges in all levels of the education system[11]. Recent ERO reports have focused on Pasifika achievement in numeracy and literacy (Education Review Office 2010; Telford & May, 2010), but there is little, if any, data on achievement in science.

'Interplay' considers the space for acknowledging, respecting, and including Indigenous values, culture, and knowledge into science education to better the experience of Tongan (and other Pasifika) science learners. As a result, the research purposefully acknowledges the existence of successful Tongan science learners, the value of their cultural knowledge, and their ability to teach the education system how to improve the teaching and learning experience of all students. It also seeks to understand the predictors of engagement, enjoyment, and success, and teaching and learning methods that support them, as identified by successful Tongan science learners.

This research project is needed because the potential outcomes strongly align with several aims of the PEP 2013-2017. These include supporting and encouraging success at higher education levels and emphasising the importance of Pasifika identities, languages, and cultures. Also, by focusing on Tongan students explicitly, this research recognises the specifics of different cultural groups and aims to refocus teaching and learning practices to lift cultural responsiveness and meet the needs of Pasifika students. This project also aligns with the Ministry of Education's Pasifika Education Research Priorities objective to "gather quality research to inform policy, decision-making and practice for improved Pasifika presence, engagement and achievement in education" (Ministry of Education, 2012, p. 11). This study will address the current disparities in education for Pasifika students by incorporating student voice. Intended outcomes include a more culturally sustaining (Paris, 2012) Aotearoa New Zealand education system, and an improvement in educator practice

[11] This research focuses on the secondary and university systems, it does not extend to primary schooling.

and pedagogy through gaining a better understanding of the nature and culture of Tongan students.

The Kingdom of Tonga context

Pule'anga Fakatu'i 'o Tonga (the Kingdom of Tonga) is made up of 169 islands and covers 700,000 square kilometres of the southern Pacific Ocean. Although 36 islands are inhabited, 75% of the total population (over 100,000 in 2016) live on the main island of Tongatapu (Ministry of Foreign Affairs and Trade, 2019). The population is predominantly ethnically Tongan (98%) with a tiny proportion of European, Asian, and other Pacific Island ethnicities (Tonga Statistics Department, 2017). Tonga is the only Pacific country with a constitutional monarchy (Ministry of Foreign Affairs and Trade, 2019). The sovereign state is in the region of the Pacific Ocean known as Polynesia but is also close to parts of Melanesia, such as Fiji, with which it has a long history of connection (Campbell, 2011).

Archaeological evidence indicates the islands of Tonga were settled about 2900-2850BP by the Lapita people[12]. There is evidence of on-going connections between these islands and other Pacific nations for trade, marriages, and other alliances over many centuries. In what was to become the Kingdom of Tonga, there were three dynasties in existence at the same time: the *Tu'i Tonga* (which began in the 10th century A.D.), *Tu'i Ha'atatakalaua* (formed in the 16th century) and *Tu'i Kanokupolo* (created in the early 17th century). Each dynasty connects back to the original *Tu'i Tonga* lineage; the *Tu'i Ha'atatakalaua* lineage branched off the *Tu'i Tonga* line and later the *Tu'i Kanokupolo branched off the Tu'i Ha'atatakalaua*. After a long period of unrest, including a Civil War from 1777-1820, Tonga was eventually united by a "unitary, centralised political system under a single monarch", Taufa'ahau, the then *Tu'i Kanokupolo,* who founded the current ruling dynasty (Campbell, 2011, p.74).

Taufa'ahau, ruling from 1845 to 1893 (also known as George Tupou 1 from 1875), began a long period of stability when much of the rest of the Pacific was experiencing unrest, often resulting in the loss of sovereignty through colonisation as in nearby Samoa and Fiji. Tonga is unique in the Pacific as it has retained its political integrity and independence; it has been ruled continuously by Tongans and has never relinquished sovereignty to any foreign

[12] The Lapita people are the first people to settle Oceania. The Lapita cultural complex, identified by a distinctive style of pottery, denotes their settlement presence.

power. Much of this can be ascribed to Taufa'ahau, who adopted many western ideas and accepted Christianity yet also focused on maintaining 'Tonga for the Tongans', for example, forbidding land sales to foreigners[13] (Campbell, 2011).

Although Tonga has been a constitutional monarchy since 1875, it operates as a highly stratified society, with inherited rank and status. Society is hierarchical, with three classes: (1) *Ha'a Tu'i* (kings); (2) *Hou'e'iki* (chiefs), *Kau Mu'a* (gentlemen) and *Ha'a matapule* (chief attendants); and (3), *Tu'a* (commoners) (Campbell, 2011). Calls for a more democratic society, signalled by increasing unrest highlighted by the 2006 riots, resulted in the legislative reforms in 2010 that allowed for partial representative elections (Campbell, 2011). Most Tongans are employed in agriculture, forestry and fisheries, and tourism. The economy is heavily dependent on remittances (20.3% of GDP) from the Tongan diaspora in Australia, Aotearoa New Zealand and the United States of America (Ministry of Foreign Affairs and Trade, 2019).

Tongan knowledge and education.

Ako is the Tongan theory of education and learning (Thaman, 1988; 2010; Māhina, 2008; Vaioleti, 2011). It underpins informal and nonformal teaching and learning in Tongan culture, particularly describing the process where specific individuals, determined by social hierarchy, imparted their particular skills and knowledge, such as navigation, to others to ensure 'cultural continuity' (Thaman, 1995). Informal teaching and learning were, and still are, predominantly carried out through observation, listening, and imitation. However, the contemporary use of *ako* encompasses learning, instruction, and the formal education system; *'ilo* (knowledge and understanding) results from *ako*; and *poto* (cleverness and skill) is achieved if *'ilo* is used appropriately and positively (Thaman, 1995). Māhina (2008) describes the practice of Tongan education (*ako*) as the process of shifting the mind from *vale* (ignorance), to *`ilo* (knowledge), and then *poto* (skill), to both remove confusion and gain knowledge and skills for the greater good of society.

The formal education system in The Kingdom of Tonga.

The current education system in Tonga has four levels: early childhood education (3-5 years old), primary (6-11 years old), secondary (12-18 years old) and post-secondary (18

[13] Tonga was not the only Pacific Island country to do this. Others include Samoa and Fiji.

years and older). According to the revised edition of the Education Act 2016, the compulsory education age is between four and 18 years old (Tonga Statistics Department, 2017). Although the reported literacy rate for those aged 15 and over is very high (99%), there are some indications that the real rates are lower than this (Ministry of Finance & National Planning, 2015).

At the time of the 2016 census, which measured the usually resident population, 94.5% of those aged 5-14 years were enrolled in school, and 71% of those aged 15-19 years old were attending school (Tonga Statistics Department, 2017). Just under half (44%) of secondary schools are run by the government, the rest are either run by churches or private organisations. The curriculum is determined by the Tongan Ministry of Education to develop students as individuals and to participate in Tongan society (Vaioleti, 2011). Although there are opportunities for higher education in areas such as agriculture, education (e.g., teacher training) and health (e.g., nursing) and several institutions offer university programmes (i.e., USP and the ‘Atenisi Institute), many Tongans complete their higher education studies overseas.

The Aotearoa New Zealand context

Like Tonga, Aotearoa New Zealand is in a region of the southern Pacific Ocean known as Polynesia. Located about 1000 kilometres south of Tonga, it is made up of three main islands and around 600 others. It was one of the last places to be settled in Polynesia, 700-800 BP, by people who developed Māori culture. European explorers sighted Aotearoa in the 17th century around the same time as they encountered the islands of Tonga and other parts of Polynesia. In 1840, Māori chiefs unwittingly signed a version of the Treaty of Waitangi, which ceded their sovereignty over Aotearoa New Zealand to the British Crown[14], making them a colony of the British Empire. Aotearoa New Zealand became independent in 1947, but the British monarch is still the Head of State. Nationally, legislative authority resides with an elected government led by a prime minister and cabinet ministers. Local governments preside over councils and territorial authorities.

[14] The Treaty of Waitangi is often called the founding document of New Zealand. However, it has a contentious history and presence in New Zealand because there are two versions, an English language version (The Treaty of Waitangi) and a Māori language version (Te Tiriti o Waitangi), which are not identical. For example, the English version uses the word sovereignty whereas Te Tiriti o Waitangi uses governance, creating on-going issues politically, socially, economically, etc. This discussion is not a focus of this thesis, but it does need to be briefly acknowledged here.

Most of the current resident population of 4.95 million people lives in urban areas, and 49.8% of the population lives in the four largest cities: Auckland, Christchurch, Wellington, and Hamilton (Statistics New Zealand, 2018). In 2018, the population comprised Pākehā (70.2%), Māori (16.5%), Asian (15.1%) and Pacific peoples (8.1%) (Statistics New Zealand, 2019c)[15]. This breakdown reflects the influence of each ethnicity on Aotearoa New Zealand culture; Pākehā culture dominates, but Māori culture and more recent immigrants from the Pacific Islands and parts of East and South Asia also have influence. Economic reforms in the 1980s resulted in a shift from a protectionist economy to a liberalised free-trade economy. Most employment is within the service sector as well as industry, agriculture, and tourism.

Education in Aotearoa New Zealand.

In Aotearoa New Zealand, education is compulsory between the ages of six and 16 years old, although most children start primary school at the age of five and finish secondary school around 17 years old. There are thirteen years of schooling organised into primary education (Years 1-8) and secondary education (Years 9-13). There are three main types of schools: state (public) schools, state-integrated schools, and private (independent) schools with most students attending state schools (Education Counts, 2019). All state and state-integrated schools are predominantly government-funded and must follow the national curriculum; The New Zealand Curriculum (NZC) (Ministry of Education, 2007) for English-medium schools or Te Marautanga o Aotearoa for Māori-medium schools (Ministry of Education, 2007). The funding by tuition fees rather than the government means independent schools must have an equivalent curriculum but do not have to follow the NZC (2007) or Te Marautanga o Aotearoa.

The NZC (2007) has eight levels (Levels 1-8) and eight learning areas: English, the arts, health and physical education, mathematics and statistics, science, social sciences, and technology (Ministry of Education, 2007). Te Marautanga o Aotearoa covers the same eight learning areas but also includes Māori language. Most secondary students are studying towards the NCEA, while some schools offer other qualifications such as Cambridge International Examinations and the International Baccalaureate.

[15] These numbers add up to more than 100% because people can identify with more than one ethnicity.

Public secondary schools in Aotearoa New Zealand aim to be egalitarian and prepare all students with the knowledge and skills to contribute to the country's economic development (McGee & Cowie, 2008; Bull et al., 2010). However, a series of educational reforms in the last few decades, influenced by globalisation processes including the 'knowledge economy', has shifted governance from a state-centred system to an individualised school system managed by each school's local community (McGee & Cowie, 2008; Coll, Dahsah & Faikhamta, 2010). This autonomy allows schools to develop their curriculum and teaching approach from a mandated national curriculum to meet their students' needs (McGee & Cowie, 2008), with an external evaluation of their performance (Coll et al., 2010). Some researchers argue that this has resulted in the flexibility of content choice that has encouraged the use of more interactive activities and pedagogies (Coll et al., 2010). However, others argue that the reforms have focused on the significance of the content delivered and disregarded the importance of the teaching and learning method of delivery used (Airini, McNaughton, Langley & Sauni, 2007).

More students are attending universities with an increasingly diverse background and varied exposure to content knowledge, creating implications for teaching and learning in the university system as staff also deal with larger classes as a result of reduced funding (Roberts, 1999). Some suggest that the traditional focus on lectures and exams may need to shift to more diverse teaching and learning methods and assessment approaches to cater to the considerable range of ability and academic preparedness within the current student body (Biggs & Tang, 2007). Therefore, we must consider the increasing diversity of students, such as Tongans, who may have different abilities, capabilities, and prior knowledge, all of which need to be acknowledged and addressed in the pedagogical approach used.

Tongan education research in Aotearoa New Zealand.

There is limited research specifically focused on Tongan student experience in Aotearoa New Zealand. The available literature falls into two broad categories which overlap with the focus of this research: highlighting concerns around Tongan student achievement (for example, 'Otunuku & Brown, 2007; Kalavite, 2010) and acknowledging the benefits of incorporating Tongan concepts and cultural practices, such as *mālie* and *māfana,* in teaching and learning approaches to address Tongan student achievement (for example, Manu'atu,

2000; 2009; ʻOtunuku, 2010; Fonua, 2018). *Mālie* and *māfana* will be discussed in detail in Chapter Two. How *mālie* and *māfana* relate to engagement, enjoyment, and success is described in Chapter Four, and their implications for science teaching in Chapter Ten.

The researcher – situatedness and positioning

I am not of Tongan heritage. In Aotearoa New Zealand I am identified as Pākehā, and in Tonga and the wider Pacific as *Pāpālangi*. Pākehā is the term used by Statistics New Zealand for any individual who resides in Aotearoa New Zealand, with genealogical links to Europe. *Pāpālangi* is the Tongan term for individuals of European ancestry. In terms of my heritage, I have Scottish ancestry through my father and Irish, Welsh, Scottish, English, and Spanish ancestry through my mother. I am married to a migrant Tongan man, we have two children together, and we live within a conventional extended Tongan family setting in a suburb of Auckland, Aotearoa New Zealand. It is my intention in this section to situate myself relative to the research problem (as outlined later in this chapter) as a non-Tongan heritage researcher, anchored within a strong Tongan familial and community context. I demonstrate my reasoning to undertake this study and to present a case for objectivity (Banks, 1998, p.6), by examining the tensions and possibilities of insider-outsider researcher positioning.

An insider is someone who belongs to a group. Insiders can benefit from a shared background, a "mutually perceived homogeneity", which, in the context of research, can promote trust and easy access to participants and data and allow for a better cultural interpretation and understanding (Merriam et al., 2001 p. 407). Nevertheless, some argue that this insider position is deceptive as it may not guarantee the authenticity or a lack of bias in the data collection or analysis (Savvides, Al-Youssef, Colin & Garrido, 2014; Merriam et al., 2001). But while an outsider researcher, who is not a member of the group, might be able to maintain a level of objectivity, they could also lack a more nuanced understanding of data, potentially misinterpreting the data (Savvides et al., 2014). Another risk is missing culturally specific nuances such as non-verbal cues and body language (Merriam et al., 2001). As such, there are advantages and disadvantages for both insider and outsider researcher positionings, given that the strengths of one are the weaknesses of the other.

Three key themes emerge when analysing such a simplistic dichotomy as insider/outsider: positionality, power, and representation (Merriam et al., 2001).

'Positionality' acknowledges the internal variation or heterogeneity of cultures and how the position of the researcher can be fluid relative to 'the other'. Depending on what is being compared (i.e., gender, social class, age), this may overshadow the cultural identity associated with insider/outsider status (Merriam et al., 2001). Savvides et al. (2014) suggest that researchers use 'critical reflexivity' to negotiate space across the dichotomy of insider/outsider. I have engaged intensively in a critical reflexive process during this doctoral research. This reflection has encouraged me to seriously consider how I continuously negotiate my positionality and how my experiences of power and representation vary in different contexts, such as my teaching and my research. I have shared different stories throughout this thesis to demonstrate my ever-evolving perspective as it strengthens and deepens.

As the researcher conducting this study, I have critically reflected on how my three 'situated positions' (Samu, 2014) may have influenced the gathering and analysis of the data. My situated positions relative to this research were: (1) as a tertiary science educator (insider), (2) as a non-Indigenous educator (outsider), and (3) as a member of a Tongan family (external-insider) (Banks, 1998).

Situated Position One—- Tertiary science educator (Insider).

I have spent almost twenty years working as an educator (or insider), in the university system, holding multiple teaching positions that have continually highlighted the inequitable outcomes in achievement for Pasifika students. I began teaching at the university twenty years ago while undertaking post-graduate study, both as a tutor in an arts faculty and as a lab demonstrator in a science faculty; my undergraduate education was in arts and science subjects. In my experience, arts (particularly the social sciences I studied) and science consider what we know differently and value different aspects of it in very different ways. As a student, I did not transition to university study easily. I struggled to find my identity as a learner, especially studying in two very different contexts; in one, I was too artsy, in the other a little bit too science-y. However, although I knew that I enjoyed learning both the broad conceptual approach of anthropology (arts/social sciences) and the detail of biology (science), my preference was always for the learning spaces and focus of the social sciences subjects I studied. In this environment we were encouraged to think for ourselves, challenge, argue and apply frameworks to understand 'how' and 'why' in ways that guided our search

for knowledge; in science I was expected to memorise and accept details about things I could not see or understand, and primarily do it by myself.

This difference in approach continued when I began teaching. As an arts tutor, I received guidelines, activities, and games, with extensive tuakana/teina[16] style guidance regarding how to deliver our content from more experienced tutors. As lab demonstrators for the science labs, we were given the lab guide to read and attended a demonstrator meeting to review content as preparation to answer any questions students may have. Although these teaching positions had different expectations placed upon them, I felt that I was far more supported to teach better, and be a better teacher, in arts.

I also found that my teaching positions, even though as a very junior member of the teaching staff, gave me insight into the obviousness of those who did not succeed. I learnt very quickly that Māori and Pacific students in my classes were unlikely to attend, engage in activities and content discussions, or to pass, but I did not understand why. Having spent the last fifteen years teaching exclusively to Indigenous (Māori) and Pasifika students, I feel I am now much better equipped to understand what was happening (or rather not happening) in my earlier classes and the wider university context. This learning is the basis of my doctoral work and what I wish to share with other science educators. This research will demonstrate how considering a learning space from a different viewpoint, perspective, or understanding, allows Pasifika students to feel included, acknowledged, and valued, and how, equally, not doing so makes them feel excluded, over-looked, and devalued.

Situated Position Two – Non-Indigenous science educator & researcher (Outsider).

For the last fifteen years, I have worked as a science educator on a programme exclusively for Māori and Pasifika students, based in a department that is Indigenous-led, where there is Indigenous oversight of the curriculum, and most staff are Indigenous. As a non-Indigenous Pākehā, this has often challenged me, forcing me to critically reflect on myself, particularly on my privilege as a *Pāpālangi*, how I engage with practice, culture and values and the power-dynamic present when I teach Māori or Pasifika students. These are

[16] The Māori phrase tuakana/teina refers to the relationship between a tuakana (older) person and a teina (younger) person. It is a common reference point with respect to teaching and learning in the Māori context.

also key things to consider when researching Indigenous or minority populations, particularly the power dynamic between the researcher and participant and how the participants' narratives are analysed and represented (Anae, 2010; Merriam et al., 2001).

According to Merriam et al. (2001), the constructing of insider vs. outsider as a binary system overlooks the "multi-dimensional power relationship shaped by cultural values, gender, educational background and seniority" (p. 408). Rather than seeing these as two distinct positions with clear boundaries, there can be fluidity between the two states and complexity inherent in either. For example, Webster and John (2010) used the term 'in-outsider' to describe the feelings an outsider researcher had when working with an Indigenous community. The task they were engaged in and the process of working together made them feel "almost like an insider–- at least during this process – maybe something like an in-outsider" (p. 182).

Because of my teaching experience, I am confident in my knowledge, understanding, and currency in the issues concerning Pasifika achievement in science. Nonetheless, as previously identified above, I do not have Pasifika ancestry, meaning I am an outsider, at best an 'outsider expert' (Samu, 2014). Therefore, as a researcher with a focus on the education of Pasifika students, I am also an outsider. Merriam et al. (2001) argue that a multiplicity of perspectives of what is an insider or outsider is required to express different interests, needs, and experiences. The 'identity conflict' that may arise from my position as both an insider educator and outsider researcher could instead be an advantage, allowing me to reflect on being both involved and on the outer (Savvides, et al. 2014). Perhaps my learnings and reflections may bring something new to things that insiders are already expected to know (Merriam et al., 2001).

Situated Position Three–- Member of a Tongan family (External insider).

These perspectives or interpretations of the researcher position helped me to explore and understand my third 'situated position': I am married to a Tongan man, I have Tongan children, and I live with my extended Tongan family for whom their first language is Tongan; as a result, some of my students identify me as Tongan. My lived experience, and thus my ontological and epistemological thinking, is now more shaped by the contemporary expressions of Tongan culture demonstrated by my Tongan family, who are based in

Aotearoa New Zealand, but maintain close ties to Tonga. This situation makes me feel that, rather than either of the binary states of insider or outsider, I am somewhere in between. By no means am I claiming to be Tongan (or an insider), but nor do I feel that I am entirely an outsider to Tongan ways and values. I believe that my worldview situates me as an "external-insider", someone who has become affiliated with an 'outside culture' and who may adopt aspects of this culture, while critically regarding many of the values and beliefs of the culture they were first socialised in (Banks, 1998).

Current positioning.

I see myself as both an insider and an outsider in the tertiary science education system. As I described above, I consider myself an insider because of the twenty years I have spent working as a university educator. I am an outsider from Indigenous spaces because I am Pāpālangi. Nonetheless, the situated positions discussed previously have informed my on-going interest in what makes Pasifika students achieve in science. Therefore, I am driven to understand why some Tongan students are successful in their science studies and what contributes to them engaging, achieving, enjoying, and continuing to study science.

The research design

In response to Hau'ofa's Sea of Islands essay, Chandra (1993) argued that the "short historical horizon academics and commentators discuss… negates the spectacular achievement of the non-Western world and should be vigorously challenged" (p. 79). As Hau'ofa (1993) states, to migrate and move throughout the Pacific, early Pacific navigators came from:

> the kind of world that bred men and women with skills and courage that took them into the unknown, to discover and populate all the habitable islands east of the 180th meridian. The great fame they have earned posthumously may have been romanticised, but it is solidly based on real feats that could have been performed only by those born in and raised with an open sea as their home (p. 10).

For Pacific people, this navigation has shifted to new contexts, instead of the ocean, they are occurring within institutions and systems, particularly those strongly influenced by western knowledge and practices. Remembering how their ancestors coped with diverse situations and challenges by relying on their ability and determination to achieve the most significant

migration in history provides a strengths-based narrative. This compelling narrative offers an alternative perspective, one that can counter the pervading deficit narrative around Pacific (academic) achievement, yet another form of the belittlement described by Hau'ofa. Considering and reclaiming their longer-term history would equip Pacific learners with ways to approach new challenges, including their engagement, enjoyment, and success in western educational institutions, spaces that are often complex and isolating. Before European explorers demarcated the ocean, "boundaries were not imaginary lines in the ocean, but rather points of entry that were constantly negotiated and even contested. The sea was open to anyone who could navigate his way through" (Hau'ofa, 1993, p. 9) – perhaps we need to consider the boundaries and lines that are deterring Pacific academic achievement in the same way?

This research focuses on critiquing and changing science education to better fit with Pasifika science learners, applying a retroductive approach to the stories of successful Tongan science learners. A retroductive approach "supposes something of a different kind from what we have directly observed, and frequently something which it would be impossible for us to observe directly" (Peirce, 1960, cited in Glynos & Howarth, 2018, p. 3). Cycling back between theory and data enables considerations of findings, allowing ideas to be shaped and reshaped as thinking is tested and refined by this tautological process (Ragin & Amoroso, 2011). It is also important to note that the style of the writing in this thesis is intentionally heavily reflective and often from the first-person narrative. The personal aspect documented is a core element of the transformation that needs to occur in education to engage Pacific learners, so they enjoy their academic pursuits and thrive.

Individual semi-structured interviews were used to collect in-depth narrative accounts of the experiences of the 26 (16 female, ten male) Tongan successful[17] science learners who volunteered to participate. Interviews were conducted in English,[18] but participants were encouraged to use Tongan words or phrases if they wished. These were translated later during transcription. These were translated later during transcription, but the Tongan retained for the analysis and explanation. The Tongan meaning of a word or phrase was

[17]Students who had passed at least two Stage 1 tertiary (or first year bachelor's level) study courses and were either current students or recent graduates (in the last three years) were interviewed.
[18]The participants were offered the option of English with the researcher or Tongan with a bilingual research assistant; all participants opted for English with the researcher.

always prioritised, particularly for those words or phrases, such as *vā*, which are used in several Pacific languages but may have slightly different meanings across these language groups. As part of the interview process, I spent time emphasising confidentiality and building connections, mutual trust, and rapport. At the end of an interview, participant time and responses were acknowledged with *me'a'ofa* (gifts). This action reflects the Pasifika values of reciprocity, love, and respect (Anae et al., 2001). I was also mindful of the perceived hierarchy of relations between myself as the teacher and the participants as students, even more so with gender differentials. This *vā* (relational space) between myself and the participants required careful, thoughtful nurturing (*tauhi vā*) in this research-based relationship (Vaioleti, 2013/2014).

With respect to language and voice, in this thesis I have purposefully chosen not to italicise te reo Māori (the Māori language) in order to normalise it and recognise its position as an official language of Aotearoa New Zealand. I have deliberately italicised the participants' stories and Tongan words to differentiate the participants' narratives and distinguish the Tongan language from Māori and English words[19]. For the same reason, I have also footnoted any Samoan words. I also intentionally capitalise Indigenous in this research as another way to challenge western hegemony in this space; capitalising signals a proper noun as a sign of respect.

Critical self-reflection.

Burnett (2012) in his analysis of post-graduate research in Pacific education carried out in Aotearoa New Zealand universities identified that most favours positivist (research that seeks to know) and interpretivist (research that seeks to understand) research paradigms over those that are seeking to change (emancipatory) or to critique (deconstructivist). He argued that this bias limits the socially transformative potential of education research as it focuses on understanding rather than challenging educational processes. Burnett (2012) urges more emancipatory, and deconstructivist research (i.e., socially transformative) needs to be done, to address calls to decolonise and re-indigenise Pacific research agendas. This research is designed to be socially transformative educational research, rather than a (valuable) source of information that did not necessarily trigger further action or sustained

[19] The exception is for headings.

change. As a non-Indigenous science educator, I have embraced the idea of critical reflexive practice by critiquing and changing my practice to be more responsive to the cultures and values of my Pasifika students and to become more inclusive of their Indigenous knowledges.

Culturally sustaining pedagogy "seeks to perpetuate and foster—to sustain—linguistic, literate, and cultural pluralism as part of the democratic project of schooling" (Paris, 2012, p. 93). It requires pedagogies to be responsive and relevant to multiethnic communities, supporting young people to maintain their cultural and linguistic competences while building cultural competence in the dominant culture. Informed by my doctoral journey, I have begun negotiating the incorporation of Pasifika values and knowledge into my teaching. I contend that to improve the quality and equity of university science teaching, it makes sense to utilise the culture of students challenged by a system dominated by a different worldview (Thaman, 2010), empowering them to reclaim and (re)present their Indigenous knowledge and cultural values.

Thesis structure

I have arranged this thesis into ten chapters. A brief description of each follows:

Chapter Two presents an overview of the theoretical framing employed in this research. It demonstrates how each of the theories, critical realism, relationality, the Multiscience Framework, and Tongan/Pacific methodologies have influenced the structure, data collection, and analysis of the research.

Chapter Three begins with a description of the research participants, including how they were selected. It also describes the methods used to collect and analyse the data and ethical considerations and limitations.

Chapter Four comprises a review of the current literature concerning the three terms, engagement, enjoyment, and success. It also presents the participants' definitions of each of these terms. The chapter also outlines which teaching and learning practices have influenced their experiences of engagement, enjoyment, and success in their secondary and university science education.

Chapter Five theorises the term Tongan science knowledge and locates it in the broader context of Indigenous (science) knowledge. It outlines what successful Tongan science

learners consider to be science and presents their understandings of Tongan science knowledge. The chapter locates science education within a WMS framework and argues for the value of acknowledging Indigenous knowledges in science education.

Chapter Six describes secondary school science education in Tonga and Aotearoa New Zealand, from the perspective of the participants. It also presents and locates the phrase the 'Tongan Education Experience' and outlines some of the myths and consequences associated with uninformed views of the Tongan education system. The chapter also discusses the realities of transitioning for Tongan science learners who move from Tonga to the Aotearoa New Zealand secondary school system.

Chapter Seven discusses the participants' experiences of secondary school science in Aotearoa New Zealand. It highlights the importance of the school culture and learning environment, the detrimental influence of deficit views of Pasifika (science) achievement, and the realities of being Pasifika and a science learner. This chapter also provides insight into how Tongan science learners manage their relationships and interactions at secondary school.

Chapter Eight delves into the participants' experiences of university science education. This chapter describes the participants' responses to the different teaching and learning environment at university and their position in it.

Chapter Nine outlines the importance of learner identity for academic achievement. It shares the participants' stories about their science learner identities, including their experiences of micro-aggressions and stereotype threat in the secondary and university-level science contexts. Importantly, this research purposefully focuses on learner identity rather than cultural identity, highlighting the differences in science learner identity between the KOTE and ANZE participants.

Chapter Ten presents the overall discussion and conclusion of the research, including a description of Fakahila, a framework with which to consider critical self-reflect as an educator and embed cultural values and knowledge in science teaching and learning spaces.

Chapter Two – Oceania as Context, Connector, and Source: Theoretical and Methodological Framings

In this chapter, the four different theoretical-conceptual perspectives underpinning the research have been woven into a cohesive framework informed by Epeli Hau'ofa's (1993) seminal essay 'Sea of Islands', and the articles of support and critique found in 'A New Oceania' (1993). Together they employ Oceania as the context, connector, and source: *Oceania as Environment* (critical realism); *Engaging Oceanic Ways* (relationality through *vā*); *Valuing Oceanic Knowledge* (the Multiscience Framework); and *Charting Oceanic Currents* (Tongan and Pacific methodologies).

Manulua

The four theoretical frameworks, visualised as a *manulua* (see Figure 1), provide different ways of examining ontology, ways of being, epistemology, ways of knowing, and axiology, ways of valuing. The *manulua* is one of the oldest known design motifs in Tongan craft, particularly regarding its presence on *ngatu* (bark cloth) (see Figure 2). It represents the wings of two birds and symbolises the coming together or union of two groups.

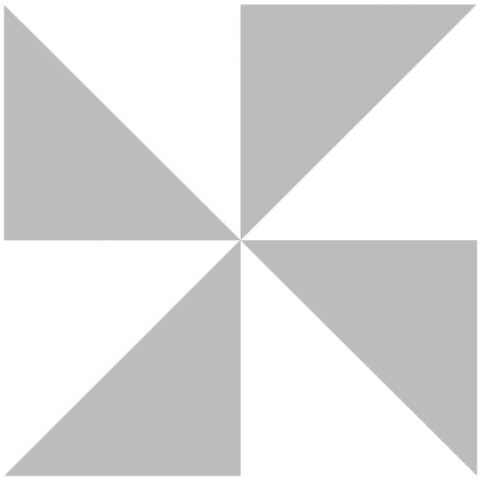


Figure 1: The *manulua* motif.

Figure 2: Ngatu featuring the *manulua* motif. Artists unknown, (year of work unknown). Author's family's personal collection.

Vaioleti (2011) referred to *manulua* as a symbolically representative way for Tongans to negotiate and balance spirituality within their daily life. I use it here (see Figure 3) to depict how each of the four theories and concepts used in this research, symbolised by the four wings of the two birds, has been woven (*lalanga*) together to form a whole, and a new way to view Pacific education experiences in Aotearoa New Zealand and the wider region. Each aspect of the four frameworks has been purposefully chosen because it brings a relevant lens to this research, enabling a critique of current science education in Aotearoa New Zealand and Tonga with respect to Tongan and other Pasifika students, the valuing of relationships

and Indigenous (science) knowledge in WMS education, and formal educational institutions and mainstream culture in general.

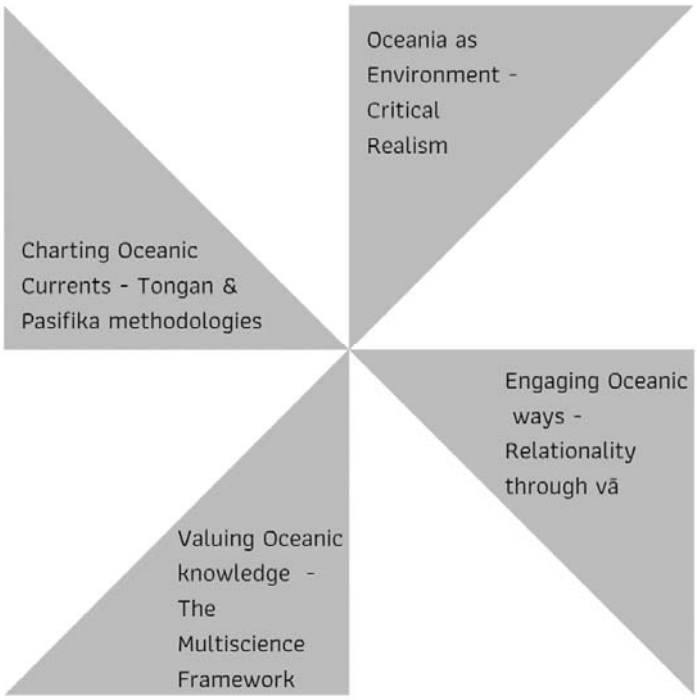


Figure 3: Lalanga manulua: using manulua to depict the four theoretical frameworks of the thesis.

Culture

Like many other commonly used words, 'culture' can mean different things to different people. For example, culture refers to "learned and shared standards for ways of thinking, feeling, and acting" (Erickson, 1986, p. 117) while "[c]ultures are meaningful orders of persons and things" (Sahlins, 1976, p. *x*). It is perhaps apt in this research to consider a definition of culture given by Thaman (1998):

> I define culture as the way of life of a discrete group, which includes a language, a body of accumulated knowledge, skills, beliefs and values. I see culture as central to the understanding of human relationships and acknowledge that members of different cultural groups have unique systems of perceiving and organising the world around them. I also believe that the ways in which we have been socialised largely influence our behaviour and way of thinking as our world view (cited in Coxon et al., 2002, p. 120)

This exploration of culture from a Tongan perspective is important for this research because of the research's focus on Tongan science learners. Although Thaman's definition emphasises cultural continuity rather than change, as Sahlins (1976) pointed out, "[c]hange begins with culture, not culture with change" (p. 22). In anthropology, culture is a very important concept. Though many early anthropologists claimed culture was "rigidly bounded, separated, unchanging, coherent, uniform, totalized and systematic" (Sahlins, 1999, p. 404), Sahlins' questions how cultures could be uniform when individuals who consider themselves to be of the same culture can be completely conflicted and contradictory in their beliefs. I agree with Sahlins (1999), that culture is not "bounded, reified, essentialized and timeless" (p. 403), and that culture does change. Therefore, to avoid any misunderstanding, in this thesis the definition of culture builds off Thaman's viewpoint outlined above but also refers to a dynamic, ever-changing body of knowledge, ways, and practices that connect a group of people.

Culture is often referred to in this research, particularly the culture of the participants themselves, the culture of the education they experience and the organisational culture of an institution. For example, although the participants are all Tongan their experience of Tongan culture is hugely variable due to their gender, socio-economic status, the level of assimilation, integration or isolation from western culture. These 'subpatterns' (Sahlins, 1999), are further complicated by their different geographical location and identity as Tongans from either Tonga or Aotearoa New Zealand. However, using Thaman's definition, these Tongan science learners could be considered to part of a discrete group. Even though the way they have been socialised and therefore behave may be different, they share knowledge, skills, beliefs, and values that make them identify culturally as Tongan.

'Sea of islands'

Epeli Hau'ofa's (1993) essay challenged the view of the Pacific as a place of smallness based on the size of the landmass valued by European colonisers and viewed from an "economistic and geographic determinist"(p.6) perspective. Instead, Hau'ofa posited the largeness of the region if the marine and the metaphysical environment is included, a position which attempts to address the historical and contemporary belittlement of the Pacific by outsiders, colonial powers and aid funders. This belittlement creates a position that

focuses on smallness of the landmass rather than the vast size of the region if the *moana* (ocean) is included, a position that in turn belittles the achievements of the people who populate this space. The belittlement includes educational achievement and the value placed on local Indigenous knowledges in formal education systems.

Although Hau'ofa's 'new Oceania' was transformative for many Pacific peoples, it also triggered some critique. This critique often highlighted an oversimplification of the Pacific situation, its diversity and its social structure and power relationships. For some, the continued use of European terms and concepts such as Polynesia maintained the colonial policy of demarcation and division (Kabutaulaka, 1993, p. 93). Other concerns included the perspective that the "smallness and isolation [of the Pacific] actually offer great potential for promoting independence from belittling and derogatory influences" (R. Thaman, 1993, p. 41). A more nuanced critique was offered by Borer (1993) who suggested that:

> [I]f viewed as a reality or as a 'truth', Epeli's vision is false. It is a phantasm, a figment of imagination, a hopeful illusion, a utopian dream, a flight of fancy, a mistaken view of our real world. If, however, it is seen as a dare, a challenge, an invitation, or a summons for the believers in a more progressive and egalitarian humanity, then Epeli's vision has some merit (p. 87).

I have taken Epeli's vision as a challenge in terms of my research. In particular the need to address the belittling and degradation of local Indigenous knowledge. I respond to this challenge by providing a lens with which to consider Tongan science learners and TSK in the learning spaces and curriculum focus of Aotearoa New Zealand's science education.

Oceania as Environment: Critical realism

"But if we look at the myths, legends, and oral traditions, and the cosmologies of the peoples of Oceania, it becomes evident that they did not conceive of their world in such microscopic proportions. Their universe comprised not only land surfaces, but the surrounding ocean as far as they could traverse and exploit it, the underworld with its fire-controlling and earth-shaking denizens, and the heavens above with their hierarchies of powerful gods and named stars and constellations that people could count on to guide their ways across the seas. Their world was anything but tiny". (Epeli Hau'ofa, 1993, p. 7)

This section will outline the meta-theory of critical realism and explain its positioning relative to positivism and constructivism regarding understanding the natural and social worlds. It also identifies the central tenets of critical realism and their influence on the research. The section is posed as 'Oceania as Environment' because of the importance of the context conveyed in the opening quote. The stories of Pacific people indicate they considered their world to include the heavens and what is found in the ocean and the underworld, both what is empirically seen and known but also, more importantly, what is possible.

Critical Realism.

Critical realism was developed by Roy Bhaskar during the 1970s and has influenced how people view the world (Danermark, Ekstrom, Jakobsen & Karlsson, 2005). It has an explicit focus on ontology, "a set of beliefs about the way the world is" (Fleetwood, 2014, p. 186), asking "what properties do societies and people possess that might make them possible objects for knowledge?" (Bhaksar, 1978, p. 13). For critical realism, knowledge is "socially produced and historically located" (Moore, 2007, p. 29) and the world is "structured, differentiated, stratified and changing" (Danermark et al., 2005, p. 5). It rejects universal claims to the truth and considers the world as a place that is stratified by time and space,

where phenomena exist whether individuals experience them or not (Danermark et al., 2005).

Critical realism is located under the umbrella of realism. Although diverse ontologically and epistemologically, realists consider the nature of reality, what is real or what exists independently of the 'knower' (Popper, 1978). Realism provides *"*a set of perspectives on society (and nature) and on how to understand them…*"* (Bhaskar, 2011, p. 2); this perspective informs how the world can be investigated and understood. As one form of realism, critical realism was developed primarily by Bhaskar in response to the 'positivist/constructivist 'paradigm wars' of the 1970s (Danermark et al., 2005). It offered an alternative position to the naïve realism of positivism, by *"*simultaneously recogni[sing] the existence of knowledge independent of humans but also the socially embedded and fallible nature of scientific inquiry*"* (Clark, 2008, p. 168).

Bhaskar countered the dominant positivist ideology of science with its focus on prediction and control with a realist understanding of science as providing *"*explanation and enlightenment" (Hartwig, 2010). According to Tikly (2015), Bhaskar also critiqued the anthropocentric positioning of much of western philosophy (and therefore western modern science) for its focus on 'what can we know' rather than 'what is'. Therefore, critical realism offers a "more sophisticated realist ontology" (Tikly, 2015, p. 243).

Critical realists believe that science can help the oppressed to understand the real causes of their oppression and offer ways to transform their position, by critiquing *"*the philosophical ideologies that stand in the way of human freedom" (Hartwig, 2010, p. *vii*). Its intention is to 'underlabour' or to provide a philosophical basis for science and social science research (Tikly, 2015), with the overall goal of human emancipation, making it a useful framework for social science research with a social justice focus.

Critical realism's central tenets.

Bhaskar offered critical realism as a philosophy of science, a way of understanding what good science is and what science does, that allows for the possibility of causal explanations without assuming universal truths (Bhaskar, 2011, p. 2). The tenets of ontological realism, epistemological relativism, judgemental rationality, and stratified ontology (Sharar, 2016) are

outlined next to demonstrate how critical realism counters other meta-theories in the philosophy of science.

Centrality of ontology.

Critical realism insists on a commitment to ontology, *"*a set of beliefs about the way the world is*"* (Fleetwood, 2014, p. 186). Bhaskar argued that to be able to understand the world we have to know it and therefore ontology cannot be reduced to what we know through direct experience. Critical realists take an *"*ontologically realist position, claiming that phenomena exist regardless of whether we know about them or not and that human social life is a part of this reality*"* (Sharar, 2016, p. 7). This contrasts strongly with positivism, or 'empirical realism', which dominates most scientific inquiry (Bhaskar, 2008) and considers that an objective world exists, as empirical or observable 'facts' that can be quantified and extrapolated to make universal laws (O'Mahoney & Vincent, 2014; Sousa, 2010). According to Gorski (2013), *"*[p]ositivists draw no ontological distinction between natural and social entities*"* (p. 660). Their *"*empirical realist ontology*"* holds that truth can be established by empirical verification achieved using 'good' scientific practice and by favouring an inductive approach (Sousa, 2010, p. 464). Thus, universal laws can be identified based on quantifiable observations; the larger the number of observations (or experiments), the stronger the correlations with causal effects and event regularities, the more predictable these laws can be.

However, the naïve realism of positivism around universal laws or scientific 'truths' has been challenged by post-positivist[20] positions since the mid-twentieth century. These critiques primarily focus on its assumption that empirical research can be used to systematically explain the world by observation and measurement, as well as seeming to ignore the inherent subjective biases of the researcher (Sousa, 2010). Instead, Bhaskar (2008) distinguished between 'intransitive' (aspects of the natural world as it is) and 'transitive' (aspects that are determined by the historical and culturally located theories which attempt to explain the real things and structures) (Shipway, 2010). This division is necessary to be able to both have knowledge and recognise that knowledge is socially mediated and therefore fallible.

[20] Post-positivist positions include post-modernism (i.e., post-structuralism, social constructivism) and realism (which includes critical realism) (Sousa, 2010).

Fallibility of knowledge.

If ontology enables the understanding of what is, epistemology informs how that can be known or the limitations of what is knowable. Critical realism critiques empiricism for the tendency to conflate epistemology with ontology. Bhaskar (1978) termed this the 'epistemic fallacy', "the idea that being can always be analysed in terms of our knowledge of being" (p. 26). This is problematic because 'what is known' starts to be considered the same as 'what is' (Shipway, 2010), reducing entities, phenomena or objects from 'what they are' to 'what is known of them' (Sharar, 2016). For example, relative to the research informing this thesis, the consideration that student engagement can be empirically determined through observable student behaviours conflates the empirical realm with the actual realm.

Positivism has also been critiqued for valuing scientific truth over other kinds of human knowledge such as 'lay knowledge' and the conflation of prediction with explanation (Sousa, 2010). These epistemological concerns resulted in shifts to other perspectives, including constructivism, which questions the likelihood of universal truths. Constructivism "consider[s] the social world to be governed by "(impersonal) discourses and powers" and the natural world to be part of the social world (Gorski, 2013, p. 661). Like positivists, they also reduce reality to what is known but social constructivists embrace 'epistemological relativism', the idea that knowledge of what is real or true is relative to a particular social group or individual. Although a strength of constructivism is in highlighting the socially constructed nature of knowledge, it has been criticised for over-privileging "human perspectives and attendant problematic variations of relativism that cannot adequately resolve competing claims to knowledge or account for knowledge development" (Clarke, 2008, p. 167).

Critical realism agrees with the constructivist notion of knowledge being socially constructed. For example, while Bhaskar considered science, or structured thought, as the pursuit of absolute knowledge (Danermark et al., 2005), his critical reading of science considered it as "a human activity that is inevitably mediated (if not determined) by human language and social power" (Gorski, 2013 p. 664). Isolating information in the manner of an experiment, or the creation of a closed system with fixed experimental variables removes the contextualisation (Gorski, 2013). This contextualisation is necessary given the social world varies because of human activity and culture, as well as the spatial and temporal context.

Critical realism agrees with epistemic relativism but uses judgemental rationality to adjudicate between theories.

Ontology is stratified.

Critical realism holds that both the natural and social worlds are stratified in time and space, so phenomena exist at several different levels and are influenced by other phenomena that occur at either the same or different levels (Tikly, 2015). This position recognises the complexity of interactions and the need to understand history to consider the future (Sharar, 2016). As a methodology it highlights the inadequacy of flat ontologies held by empiricists who only consider observable phenomena and their occurrence at one level, a "flat surface whose characteristics, such as being constituted by atomistic facts, were determined by the needs of a particular concept of knowledge" (Bhaskar, 2008, p. 35). Instead, critical realists believe the examined phenomenon is likely to be the result of processes occurring at a different level (Sharar, 2016).

Bhaskar (1978) suggested that what is known is, or how phenomena are experienced, can be conceptually categorised into 'realms'. These relatively autonomous realms or domains, the 'real', 'actual' and 'empirical', are subsets of understanding informed by what is known and demonstrate the depth of reality (Tikly, 2015). For example, within the domain of the 'real' exists all possibility or all the causal mechanisms, structures and relations that exist in the world. These mechanisms and structures generate events in the natural world; relations generate behaviour in the social world (Shipway, 2010). Within the subset of the 'actual' realm exists what has become possible or all the mechanisms that have been activated even if not observed, and includes the events generated by the mechanisms described in the realm of the 'real'. The subset of the 'empirical' contains what has been detected or noticed or the mechanisms that have been activated and observed, such as an individual's experience of events (natural world) and behaviour (social world) (Shipway, 2010). Critical realism urges that to understand the world and causality, it is necessary to shift focus to the realms of the actual and the real, rather than the realm of the empirical as favoured by positivism.

Critical realism also argues that understanding particular past phenomena cannot allow precise predictions of future events or occurrences of the same phenomena because there

are other factors at play. Critical realists hold that perspectives are always situated and any attempt to explain and understand anything about the world is influenced by our concept of it (Danermark et al., 2005). They argue that developing an understanding of the natural world (or natural sciences) and the social world (or social sciences) solely through scientific experiment and observation can be problematic.

As experiments cannot be used in open systems, the focus of critical realism's methodology is on abstraction and abduction (Danermark et al., 2005). The focus of critical realism is on explanation rather than prediction. This explanation is predicated on finding the structures and mechanisms that produce events. Bhaskar acknowledged that the world *"*includes phenomena that exist independently of any knowledge*"* (Sousa, 2010, p.464) and the world is *"*complexly brought about by interlocking causes*"* (p. 460).

Locating critical realism in this research.

Critical realism underpinned the ontological position of this research primarily through the perspective of a stratified reality, the emphasis on explanation and using retroductive analysis as described below.

Science as a discipline.

> We should not forget that human reality is human creation. If we fail to create our own someone else will do it for us by default (Hau'ofa, 1993b, p. 129).

This research explores the experiences of successful Tongan science learners. Therefore, by studying an aspect of the social world, it is social science research seeking to understand phenomena that are *"*both socially produced and socially defined*"* (Danermark et al., 2005, p. 16). However, the focus on science education also requires the recognition that the phenomena discussed as science (or natural science) in science education are *"*naturally produced but socially defined*"* (Danermark et al., 2005, p. 16). These phenomena are also primarily located within a western understanding of the world.

The history of the development of western scientific thought is long and complex[21]. Importantly, it required the shift from considering theological or supernatural explanations of

[21] Science, or WMS, has been strongly influenced by many different cultures. Although, this is not the focus here it must be acknowledged.

the world as the truth to emphasising and searching for reason and logical and rational explanations using a particular scientific method (Sousa, 2010). This method requires that scientific investigations include "observation or experimentation of phenomena; formulation of hypotheses concerning the phenomena, via 'induction'…; tests to demonstrate truth or falsity of proposed hypotheses, through 'deduction'…; and finally, the verification of or the need to modify hypotheses" (Sousa, 2010, p. 458). Therefore, what is seen as valid scientific knowledge is that which has gone through such a validation process.

Ultimately, science[22] (read WMS) has been defined by Sousa (2010) as:

> [the] rigorous and time-consuming activity through which the world is systemically inquired, described, and explained – though one is likely to take science as including all the outcomes produced by that activity. Science pertains to the production and use of theoretical and empirical knowledge by scientists (i.e., scholars and researchers) and to that scientific knowledge per se (p. 457).

In this research 'science'[23] is used as a placeholder for WMS (see 'Oceanic knowledge' below). Other terms are used in this research to reference the science knowledge of two very different contexts. These two definitions include: 'school science knowledge' which refers to the formal, informal and hidden science curriculum experienced in secondary schools; 'university science knowledge' refers to the formal, informal and hidden science curriculum experienced at university.

Although some suggest that positivism's grip on science has waned slightly since the mid-twentieth century, others argue that linguistically it is still well entrenched and that the positivist position continues to dominate the "current orthodoxy within scientific communities" (O'Mahoney & Vincent, 2014, p. 6). Since beginning this research journey, I have often wondered how many other science educators have considered the influence that positivism has on them. Additionally, how has the empirical and reductionist approach of their formal science education informed their understanding of science? Moreover, how has their ontological and epistemological positioning influenced their approach to science education? Could this be a contributing factor to why Tongan and other Pacific students are

[22] When science is used here it is referring to a specific body of knowledge, namely WMS, rather than science as a universal phenomenon. Chapter Two elaborates on why using the term WMS is essential for distinguishing and identify the privileging of a particular cultural knowledge.
[23] 'Science' will be used until the discussion of the MSF later in this chapter.

not achieving in science akin to other ethnicities? If various government policies and initiatives have not achieved an improvement in Pacific student achievement over the last few decades, perhaps it is because they have not required educators[24] to consider a shift in their ontological position.

The challenges critical realism applies to positivism are extremely important considerations for science educators to be exposed to, to reflect on and to debate. If positivism dominates science then it follows that most science educators, particularly those at universities, have been exposed to a positivist ontology through both their education, and their academic and teaching pursuits. As such, they have usually spent their lives focusing on "a 'flat actualism' that does not probe underlying structures and causal mechanisms that may be beyond perception" (Tikly, 2015, p. 243). In contrast, critical realists consider how the social world is shaped by the intransitive dimension, which consists of deeper causal mechanisms and structures such as social inequity (Tikly, 2015). These invisible, yet influential forces, including the cultural, political, economic drivers present, can affect what is considered normal, usual, and valued, and ultimately, what is real and how knowing is enabled (Gorski, 2013). For the most part, university science educators are employed for their research capabilities rather than their teaching experience. As a result, reflecting on how forces contribute to a social situation, such as why some students are not achieving in their course, are not usually part of these educators' focus, interest or consideration. Instead, student outcomes in the form of marks or grades, are an empirical, quantifiable result that they may or may not have to justify or explain.

I suggest critical realism's central tenets, such as stratified ontology, are useful ideas for science educators to consider. The critical self-reflective experience of this research enabled me to consider how this level of reflection in other science educators could trigger an ontological shift that may contribute to improving the experience and outcomes of Tongan (and other science learners). For example, Bhaskar's (1978) correlation between the three realms of a stratified reality and mechanisms, events, and experiences provides a means to understand how different realms influence which knowledge is emphasised, noticed or

[24] This is a particular concern for university-level science where those employed to teach are more often than not trained scientists rather than trained teachers.

valued. For example, it is a major ontological shift to acknowledge ‘what is’ consists of more than ‘what is proven’ or ‘what (an individual) knows to be true’.

Engaging Oceanic Ways: Relationality

"the individual – the self- does not exist. One exists only in reference to others. Hence the practice of always consulting, meeting, talking matters out, such that all decisions are fundamentally collective ones, based on a remarkable degree of consensus. While such a way of proceeding may be tedious and unproductive to the rational, Western mind… there is something fundamentally generous about such a way of proceeding, where dialogue, debate and collective searching are at the centre of our preoccupations."
(Waddell, 1993, p. xiii)

Critical realism argues that reality is multidimensional and stratified; it is an open system with infinite possibilities where causal laws are ontologically distinct from the pattern of events. This ontology enables a contextual understanding of time and space that creates significant room for the focus on relationality in science education that follows. Both context and chronology are also important in Tongan culture. Māhina (2008) describes *tā* and *vā* (time and space) as inseparable and occurring "in plural, collectivistic, holistic and circular ways, as opposed to the singular, individualistic, analytical and linear manner" (p. 78) of the West, while Vaioleti (2006) highlights the need for contextual interaction to create authentic knowledge when working with Tongan participants.

Vā, or the relational space, is a viewpoint found in many Pacific countries, including Tonga, Samoa, and Fiji. *Vā* can be variably understood as the space where relationships or interactions occur, the 'socio-spatial' connection between, and is also associated with balance in relationships (Airini et al., 2010). The *vā* is never empty space but filled with the relationship that exists between two people, groups, or entities; there is always some kind of relationship, whether positive, negative, supportive, or derogatory, and the two involved both have responsibility for how the relationship works. Like the opening quote from Waddell (1993) explains, interactive, collaborative, and collective relationships are essential in Pacific

cultures. From a Tongan academic perspective, *vā* "emphasises space in between. This is fundamentally different from the popular western notion of space as an expanse or an open area" (Ka'ili, 2005, p. 89). It is a "…relational space between two time-markers (*tā*). It is a space that is fashioned through the relationship between time-markers – beats, things, or people" (Māhina, 2004). The importance of *vā* is evident in the numerous Tongan terms that detail the intricacies of this relationship, for example, *tauhi vā*, which refers to managing the relational space (Ka'ili, 2005), emphasises the importance of nurturing the relationship rather than the persons involved; whereas *tauhi vaha'a* is looking after or protecting the space (Thaman, 2008).

As other researchers have also suggested (see Ka'ili, 2005; Mila-Schaaf, 2006; Reynolds, 2017, 2018), understanding *vā* can help educators working with Pasifika students to consider the embodiment of relationality in their teaching and learning spaces, especially when located in the Pacific. Relationality refers to *"*our lived relation to other human beings, other living creatures, and to the non-living entities with whom we share our spaces and the planet*"* (Ritchie, 2013). Although relationality is often reduced to relationships its essence is broader, encompassing any type of association or link with anything. Relationality replaces the linear idea of connection with a connection through an expanse of space. For Tongans, *tā* and *vā* are inseparable constructs that shape who they are and how they position themselves relationally. According to Fa'avae (2019):

> Tā relates to time, but it can also relate to age, history, generation/s and gender. Vā, meanwhile, denotes the physical, spiritual and emotional spaces that exist between objects and people, within the mind and in the heart. Vā is also symbolic of "place" (land/home) or "space" in terms of social reality, vā is a space where one's sense of self is positioned and shaped (p. 6).

The various cognates of v*ā* that exist in the Tongan language also stress its importance and explain its significance, for example, *vaha'a*, which refers to *"*a space between two objects that [are] treated as if it were an object itself*"* (Ka'ili, 2005, p.90).

For those who are new to relationality or *vā*, the conceptualisation of a valued relationship or connection with non-living entities may seem unusual. Nonetheless, this is not uncommon across the Pacific, as evident in Hau'ofa's (1998) description of the connection between Pacific peoples ("us") and their universe at the beginning of this section. In it, he

outlines how the strength of the relationship between the ocean and "us" makes these two entities interchangeable but also inseparable. He argued that,

> All our cultures have been shaped in fundamental ways by the adaptive interactions between our people and the sea that surrounds our island communities. In general, the smaller the island the more intensive the interactions with the sea, and the more pronounced are its influences on the culture of the island. However, one does not have to be in direct interaction with the sea to be influenced by it. Regular climatic patterns, together with such unpredictable natural phenomena as droughts, prolonged rains, floods and cyclones that influence the systems of terrestrial activities are largely determined by the ocean (p. 403).

In essence, Hau'ofa is emphasising that it is the constant and unavoidable interactions or relationships with the sea that have 'shaped' the expression and possibility of Oceanic cultures; the same people located elsewhere geographically are unlikely to have had the same relational experience.

There is a significant overlap between critical realism and relationality in that they both argue that not everything is observable. If we replace the sea with educator or teacher and the land with Pasifika students, it is possible to use this explanation to demonstrate the significance and far-reaching influence of the teacher-student relationship on 'shaping' student academic outcomes. It also highlights the influence of unobservable causal mechanisms operating at different levels on this relationship and students' academic outcomes, represented here by weather patterns. Like understanding *vā*, conceptualising relationality can demand a shift in positioning and the recognition that reality is deeper than what is empirically understood and culturally informed, as explored in the following section.

Relationships in education.

The importance of relationships has been emphasised in Pacific research for many years, and educators have been consistently encouraged to form 'good' or quality relationships with their Pacific students. Research on the significance of relationships for Pasifika students has demonstrated how engagement and achievement are affected by the quality of the relationship with their teacher(s) (Hawk & Hill, 2000; Reynolds, 2018). However, the idea of relationships and what makes them 'good' is not universal; labelling

relationships as good or quality becomes culturally loaded as different cultures understand 'good' in different ways (Thaman, 1998).

Instead, the significance of the expression of the student-teacher relationship and its impact on Pasifika student academic outcomes must be recognised. Deficit theorising of Pacific students, by linking teacher expectations to student ethnicity, has been demonstrated for over fifteen years, if not longer (for example, Alton-Lee, 2003; Nakhid, 2003). This also echoes the link between academic outcomes and ethnicity identified by recent PISA testing. What needs to be recognised is the role that teachers play and their agency in maintaining these stereotypes, how their actions continue or expand these problematic depictions of Pasifika students, and, ultimately, the impact on the students themselves. For example, 'Otunuku and Brown (2007) found that teachers prioritised the self-efficacy of Tongan students over the content difficulty, believing it necessary to favour their students' emotional state over their future academic performance.

Perhaps shifting educators to a broader understanding of what is culturally valued is more useful than trying to determine what quantifies a good relationship. Ka'ili (2005) notes that the skill required to migrate into the Pacific is now recognised but not the "complexity of the socio-spatial ties linking Moanans[25] to one another across such a great expanse of physical space" (p. 86). He explains the importance of reciprocity to all Moanan cultures and its importance in maintaining relationships. In Tongan society, this involves core principles such as '*ofa* (love and generosity), *faka'apa'apa* (respect), *fetokoni'aki* (mutual assistance), and *tauhi vā* (caring for sociospatial relations) (Ka'ili, 2005).

If educators consider *vā*, particularly the expectations, ethics and responsibilities of *tauhi vā*, this "leads to an examination of our interaction with others; a focus on our intentions and conscious actions that influences the nature of our relationships with others" (Mila-Schaaf, 2006, p. 11). In education, this is particularly important for how teachers and students interact, relate, and work with each other. The critical realist lens described in the previous section emphasises a stratified ontology that indicates that the teacher-student relationship is more than the hegemonic teacher-student differential. The social, cultural,

[25]Used by some researchers instead of Polynesian, *moana* (and Moanan) recognises connections to the Pacific Ocean and highlights Oceanic culture (see Ka'ili, 2005).

economic, and political forces identified above influence this relationship, as well as how these forces influence each person in the *vā in* different ways.

Locating *v*ā in this research.

According to critical realism, education cannot be neutral because of the multiple forces that influence what education is, what it is for, and who it is for. As a result, science education cannot be neutral, no matter how unbiased or objective scientists think they are. Instead, humans are inherently relational; we are social creatures who need social interaction. I would argue that current science and science education that is heavily influenced or inspired by WMS tries to avoid relationships, to its detriment. Presuming that it is possible to remove 'self' from any interactions creates complications and is perhaps one of the many elements contributing to the current state of Pasifika achievement in science?

'The Sea of Islands' will be used to consider how relationality in the form of *vā* applies to science education and this research, raising questions about how the gap between a positivist approach to education and an understanding of *vā* may influence Tongan (and non-Tongan) science learner engagement, enjoyment, and success. Although the importance of the teacher-student relationship has been stressed to educators of Pasifika students for a considerable period, there are indications that it does not always translate into practice. For example, most of my participants described relationships with science teachers that were not 'good' or even positive. This concerns me and makes me wonder why some educators do not form good relationships with their Pacific students, or what is preventing these relationships from being considered as 'good', helpful, caring or supportive by, in this case, Tongan science learners, even though suggestions exist (for example, Thaman, 2008). Perhaps these educators are assuming a different identity when they teach, changing their demeanour and way of interacting (Reynolds, 2018), or maybe it is their ontological positioning clashing with that of their Pasifika science learners.

Hau'ofa (1993) described Oceania as a 'sea of islands' rather than 'islands in a far sea', offering a more 'holistic perspective' that encompasses the 'totality' of relationships, countering the dominant deficit 'smallness' description associated with Oceania geographically and economically. Instead, he acknowledges the breadth of Oceania and its

wealth of knowledges, cultures, and history that exist beyond imposed colonial boundaries and narrow perspectives. For Hau'ofa (1993):

> If we look at the myths, legends and oral traditions, and the cosmologies of the peoples of Oceania, it will become evident that they did not conceive of their world in such microscopic proportions. Their universe compromised not only land surfaces, but the surrounding ocean as far as they could traverse and exploit it, the underworld with its fire-controlling and earth-shaking denizens, and the heavens above with their hierarchies of powerful gods and named stars and constellations that people could count on to guide their ways across the seas. Their world was anything but tiny (p. 7).

This description of Oceania as a place of purposeful and intentional connection counters that of the perspective initially purported by European colonisers that the Oceanic population was unintentional and random in their existence - as a student of anthropology, I am very aware of this tension and its implications for explaining history. Hau'ofa's perspective raises the importance of ontological positioning discussed in the previous section; seeing the islands as connected, a 'sea of islands', or disconnected, 'islands in a far sea', will determine what is, and therefore what is possible, in that space.

This research shares the 'sea of islands' view of reality, seeing possibility, capability, and purpose. The focus on successful Tongan science learners counters the deficit perspectives of Tongan (and other Pasifika) underachievement in science, and that success in science as a Tongan (and other Pasifika) science learner is a rare and accidental phenomenon. The emancipatory nature of this research intends to change the often-distorted version of the truth, particularly around what is considered valued knowledge. Like other researchers who have embraced Hau'ofa's work, Reynolds (2017) notes the parallels between the separation and connection of islands in Oceania and relationships in the classroom. My contribution is the suggestion that if we specifically shift the view of science educators away from Tongan (and other Pasifika) students as 'islands in a far sea' to 'a sea of islands' that are connected socially and spatially, we highlight and emphasise the need to reduce the conscious (and unconscious) bias towards Tongan science learners.

Teachers and educators also need to recognise that these connections and separations in classroom relations are perhaps more apparent in a subject that derives knowledge from an investigative method that seeks to avoid subjectivity or human influence. It is then that

more science educators will recognise the role they play in acknowledging the diversity of viewpoints and knowledges in their classrooms and teaching spaces, as well as their role in maintaining the relational space.

Oceanic knowledge: Valuing and framing

"Perhaps one of the saddest manifestations of cultural breakdown, belittlement and educational dependency… is the deterioration of Pacific languages. …For preliterate societies, such as those of Oceania, this becomes a particularly heinous crime. In the absence of the required level of sophistication in vernacular 'thought languages', the myths, genealogies, technologies, plant and animal names and their uses, and the traditions that give Pacific societies positive self-images and autonomy will be degraded or lost, and along with them many of Epeli's powerful and expansive Oceanic tradition"
(R. Thaman, 1993, p. 45)

The science taught in many schools in both developed and developing nations is more often than not based on the WMS way of knowing (Aikenhead, 2006). Also, the subject of 'science' generally expects acceptance of WMS as a universal truth, with specific values, techniques, and objectives that align with positivist notions of scientific knowledge that "feed on reductionistic and mechanistic practices in order to celebrate an ideology of power and dominion over nature" (Aikenhead, 2006, p. 387). It also reflects the colonial legacy of a Eurocentric education system, which often marginalised Indigenous ways of considering and interacting with nature while promoting western ways of knowing and understanding the world. As Thaman (1993) notes in the opening quote, the loss of cultural knowledge such as language can result in the degradation of what was once positive self-imagery, an ongoing issue for Indigenous peoples dominated by western knowledge systems. One response to this has been the development of the Multiscience Framework (MSF), which instead offers a pluralistic perspective on what science is and allows for all cultures to have their own science (Ogawa, 1995). This section outlines the MSF and how it has informed this body of research with its particular emphasis on the importance and value of ISK in science education.

The Multiscience Framework.

Emphasising WMSK in school curricula impacts the relevance and relatability of science content for Indigenous students, and often their retention, especially in the senior years (Aikenhead, 2006). As a result, many Indigenous students experience a school science that "overtly and covertly marginalizes Indigenous students by its ideology of neo-colonialism – a process that systemically undermines the cultural values of a formerly colonized group" (Aikenhead & Elliott, 2010, p. 324). Science education contributes to the maintenance of these concepts when it is posed as a universal truth, an authoritarian truth, rather than one form of knowledge among many others that understand the world in different ways (McKinley, 2007).

In contrast, incorporating a pluralistic approach addresses diversity and encourages and nurtures the relationships within the classroom, enhancing the non-Indigenous understanding of Indigenous knowledge and wisdoms. Several Tongan researchers have stressed the importance of using Tongan knowledge (for example, Manu'atu, 2000, Thaman, 2003, and Vaioleti, 2011). More recently, Fa'avae (2019) argued that "disrupting ingrained thinking is possible when using Tongan or *Moana* people concepts that allow for deconstructing, re-focusing, and rethinking that is centred on Indigenous views of the world" (p. 6). Adopting a pluralist approach or pluralistic curriculum by incorporating multiple perspectives goes some way to address diversity and can encourage a non-Indigenous understanding of Indigenous ways of knowing. For example, multicultural science education can either encompass acknowledging the contribution of non-western cultures to science or the need to consider the diversity of cultures in the science classroom. Yet, the MSF challenges this as not enough, and postulates that we should instead acknowledge that all cultures have science, by defining science as "a rational perceiving of reality," where "perceiving" means both "the action constructing reality and the construct of reality." The merit of the use of the word "perceiving" is that it gives science a dynamic nature" (Ogawa, 1995, p. 588). As this rational perception of natural phenomena is heavily influenced by cultural worldviews, celebrating multiple perspectives also challenges the "hegemonic role that Western science plays in a rapidly globalizing world" (Hammond & Brandt, 2004, p. 2).

The MSF proposes the creation of a different, more inclusive pedagogical perspective and learning space for science learners. Besides WMS, Ogawa (1995) urges the recognition of

two more levels of science: individual and societal or cultural, emphasising 'personal science' because learning is an individual phenomenon within a social or cultural context. He defines 'personal science' as a "rational perceiving of reality which is unique to each individual" (p. 588). It is informed by the individual's Indigenous science which is also "a rational perceiving of reality", with a worldview and corresponding rationalism that is culture-dependent and collectively lived and collectively experienced (p. 587). Although WMS has its own "rationality and has its respective worldview", personal and Indigenous science relate to an understanding of natural phenomena that occur in the 'every-day life world'. On the other hand, we can consider WMS as one way to understand a reductionist 'theoretical world', or "one way of describing and interpreting natural phenomena" (p. 584). Ogawa (1995) suggests scientific theory is "a tentative representation of an assumed reality" (p. 585). It is not a given that someone from a western country can automatically understand WMS; Ogawa (1995) suggests understanding comes from being able to understand the 'rules' of the WMS 'game'. Such a pluralist perspective creates the opportunity for an equitable approach to different forms of knowledge and aligns well with the critical realist perspective discussed previously. The MSF was a critical influence on this research as explained below.

Locating Indigenous knowledge in this research.

Ogawa (1995) suggests that teaching science from a Multiscience perspective, rather than a multicultural science education perspective, would both acknowledge that other sciences that exist and drive "richer implications for reflection and practice" for science educators (p. 583). A Multiscience approach also acknowledges that students from non-Western cultural groups are constantly negotiating the demands of their formal Western education and their cultures (Thaman, 2010), a process described by some as 'cultural border crossing' in science (Aikenhead, 1996). The stratified ontology viewpoint of critical realism also acknowledges and understands the hierarchy and power differential created around the scientific knowledge of different cultures. If educators understand and adopt a pluralistic perspective of scientific thinking, rather than assuming universalism, it opens the opportunity to include Indigenous knowledges (IK) and, subsequently, culturally responsive science education. As Bhaksar (1978) suggests, our world would be a different place if other philosophical understandings of the world had been adopted instead of those which have

defined the trajectory of our scientific knowledge, namely "positivism … [which has] fashioned our image of science" (p. 12).

Internationally, many previously colonised countries have been dealing with how to develop culturally relevant curricula that suit their culture and history, complicated further by the hegemony of Western culture in this time of globalisation and the heterogeneity of different cultural groups (Tikly, 1999), for example, Canada (Akenhead, 1997) and Australia (Hansen, 2016). According to the NZC (2007) Science Learning area, students will learn how "[d]ifferent cultures and periods of history have contributed to the development of science" (p. 28). This statement suggests a focus on scientific knowledge, method, and process with some allusion to non-western modern scientific knowledge. This focus aligns with the position taken by this study, in which I have purposefully chosen to use the terms 'Indigenous Science knowledge' (ISK) and 'Tongan science knowledge' (TSK) alongside western modern science knowledge (WMSK). Instead of referring to this as wisdom, described as patterns of everyday life (Sanga, 2016), I use ISK because it is well recognised in the literature (e.g., Aikenhead, 1996, 2001; Ogawa, 1995). More importantly, this position also achieves the pluralist and equitable approaches suggested above.

In the anthropology of education, culture has been defined as "patterns for living, acquired through socialization and enculturation, and passed on and modified by each generation" (G. Spindler, cited by Hammond & Brandt, 2004, p. 3). As such, WMS has been considered by some to be a subculture of western culture, a group within a culture that has systems of meaning and symbols that convey identity and aid social interaction, because it shares a well-defined system of norms, values, meanings, and symbols (Aikenhead, 1996). The prestige and power associated with western culture and WMS often allows it to assume priority in non-western cultures. As a result, WMS can displace the local IK, usually through assimilation or acculturation, causing some to label WMS as a "hegemonic icon of cultural imperialism" (Cobern & Aikenhead, 1997, p. 3). Therefore, I considered it necessary to adopt Ogawa's Multiscience education perspective with its intention that all sciences have equal ranking to ensure representation of all cultures, or at a minimum, relate to the science education delivered in Aotearoa New Zealand. The NZC (2007) suggests diversity as an observable value, as in valuing "diversity as found in our different cultures, languages and heritages" (Ministry of Education, 2007, p. 10). Also, within the NZC's range of key

competencies are 'respect' and 'relating to others' and the principles include cultural diversity, inclusion, community engagement, and future focus. I would argue that adopting a Multiscience education perspective would enable these values, competencies, and principles to become a reality for science learners in the education system of Aotearoa New Zealand and increase the relevance of IK. Multiscience education is important to my research because of my interest in ISK and the increasing presence of Tongans in the education system.

The MSF perspective also recognises that learners do not need to change their culture to learn science. Aikenhead (1996) describes the process of science learners moving from the familiar cultures of their families and peers into the subculture of school science and science as 'cultural border crossing', an activity that is critical to learning science. If during the process of learning, the subcultures represented are similar or the values align with their culture, the student can become enculturated into scientific thinking. For students whose cultural identity contradicts or is disrupted by the subcultures of science and school science, it can negatively impact their learning.

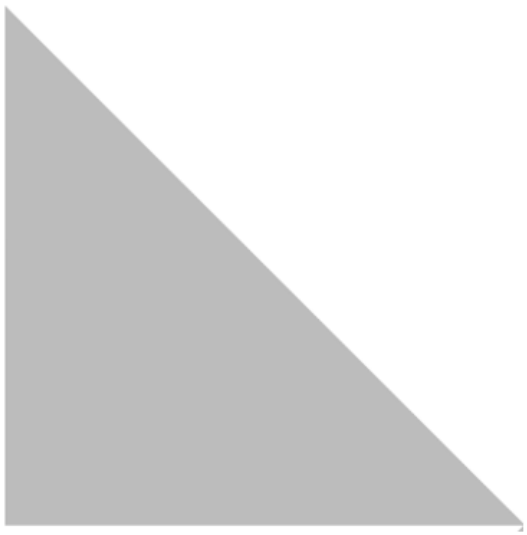
Border crossing is a useful perspective by which to consider successful Tongan science learners relative to their science education, as it acknowledges the impact of learning science but also the diversity of responses possible in the science learner. If the education system truly wants to see Pasifika learners achieve, the diversity of experience, learner response to education and their learner identity must be recognised to be able to transform the education system to a place where Pasifika learners thrive, recognise and experience the valuing of their knowledge and wisdom, and are encouraged to be themselves.

Diversity.

The NZC (2007) mentions diversity in multiple places: acknowledging cultural diversity as a principle of NZC (2007); as a value that is to be "encouraged, modelled and explored" in reference to "diversity as found in our different cultures, languages and heritages" (Ministry of Education, 2007, p. 10); and the idea that students "appreciate that diversity is a key to unity" (p. 14). Diversity is also noted specifically for "the diversity of life and life processes" (p. 28) in the subject of science and effective pedagogy, which requires that "[e]ffective teachers attend to the cultural and linguistic diversity of all their students" (p. 34).

It is important to be clear what is meant by diversity so that the solutions proposed to respond to said diversity makes sense. Almost fifteen years ago, Alton-Lee (2003) noted that educational outcomes suggest that the education system needs "to be more responsive to diverse learners" (p. 8). Different interpretations of diversity can include ethnicity, age, language, ability and so on; yet responding to diversity needs to respect similarities and differences and shift perceptions about any divergence from a perceived norm as bad or deficient. Samu (2011) categorised discourse around diversity in three ways: (1) as a way of categorising variation, often using 'observable' characteristics such as ethnicity, age, language spoke, to drive a sense of 'otherness', (2) as applied to educational practice and (3) as a driver for educational focus. In this research I subscribe to the view that diversity can be cultural, intracultural and economic (Coxon et al., 2002), meaning it is both demographic (i.e., socio-economic status, educational background etc.), labelled in this research as 'demographic diversity', and as an element that is important for enhancing social cohesion. By improving educators' understanding and insight into the experiences of Tongan science learners, themselves an observably (and un-observably) diverse group, this research will diversify science education in Aotearoa New Zealand.

Charting Oceanic currents : Key methodologies



"To change the mind set will require not just an evocative and fresh statement on how we are as islands and people in the Pacific but it must also include the clouds on the horizon as well. Pacific islanders travelled by looking up at the stars, but by following the weather as well, gauging currents and attempting to determine where the ocean was taking them"
(Griffen, 1993 p.62)

Researchers must ensure that the approaches they use are appropriate to answer their research questions, the value of the research, and justify the involvement of the research

participants. When working with Pasifika, it is important to consider and utilise Pasifika frameworks, and knowledge systems to acknowledge traditional values and epistemologies (Anae et al., 2001) positioned here as Charting Oceanic Currents. This analogy demonstrates that, like the Pacific navigators described above, we must know where things are coming from, going to or how they are connected and influenced by everything else to know which decisions to make or in which direction to travel.

The research focus on Tongan science learners necessitates using Tongan specific approaches and frameworks such as the *Kakala* model (further developed into the *Kakala* Research Framework (KRF) and used by researchers such as Fua, Manu, Takapautolo & Taufe'ulungaki, 2007) and the practice of *talanoa*. Both had a strong influence on the methodology. Several other Pacific research methodologies and methods used in education research have also been relevant to this research: Teu Le Va[26] (Airini et al., 2010; Anae, 2010) and the Ethnic Interface Model (Samu, 2015). The engagement with different methodologies and methods aligns with the critical realist perspective, which encourages the use of multiple methods; each methodology will be discussed in turn next.

Tongan methodologies – *Kakala* Research Framework and t*alanoa.*

Kakala is the Tongan practice of weaving garlands from flowers and other plant materials. The process of making *kakala* is very important to Tongan culture, and the practice of making these garlands has become standardised using patterns and vocabulary developed over time. Thaman (1997) was the first to employ *kakala* as a metaphor and model for an education research framework. In this metaphor, the three stages of construction, *toli*, *tui*, and *luva*, represent data collection, data analysis, and the application or implementation of knowledge gathered during the research process, respectively. This model has been successfully used in education research projects and has been further developed into the KRF, which includes another three stages: *teu*, *mālie,* and *māfana* (Fua et al., 2007). In the KRF model, teu is the conceptual stage of the research process, *mālie* highlights the relevance and worthwhileness of the research, and *māfana* represents the application of the data, transformation, and sustainability (Fua et al., 2007; Chu, Abella & Paurini, 2013) (see Figure 4).

[26] Teu Le Va is a Samoan phrase that means to care for the relational space.

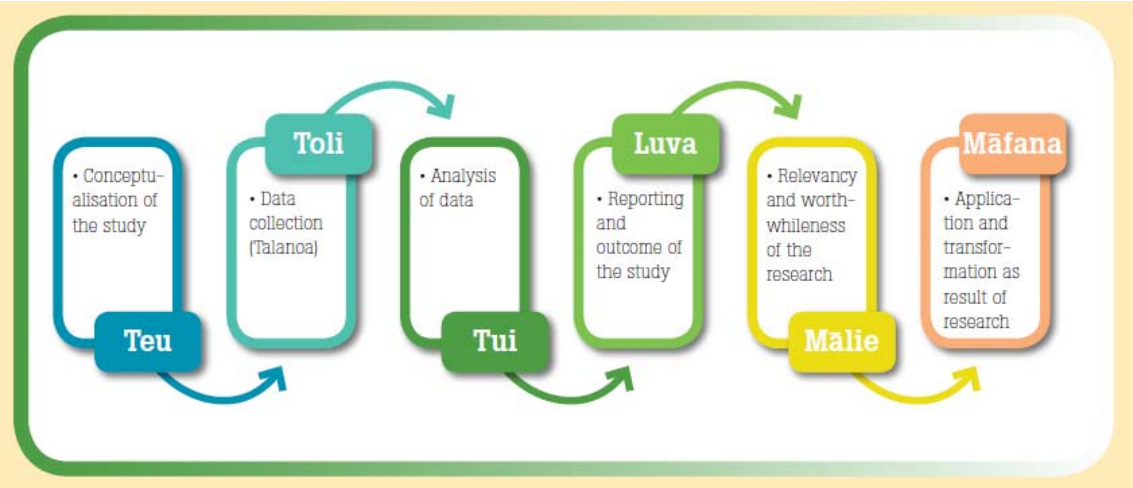


Figure 4:The Kakala Research Framework. Retrieved from Chu et al. (2013).

Kakala is an important aspect of Tongan culture, capturing many key Tongan values and traditions and, as a framework for education research, it centralises the importance of IK systems. The KRF is especially valuable to my research as I have aimed to explore concepts of Tongan IK and what science means to Tongan science learners. Using Tongan methodologies also addresses concerns that intra-ethnic nuances could be missed when pan-Pacific approaches are applied (Airini et al., 2010; Anae, 2010).

The KRF collects data using *talanoa*, a qualitative approach that allows participants to tell their stories and experiences. *Talanoa*, literally translated as "talking about nothing in particular, and interacting without a rigid framework" (Vaioleti, 2006, p. 23), allows the participant to reflect on the research topic, providing their critique and argument. *Talanoa* is complex but flexible because it is a conversation that can be formal or informal and can be used in different contexts or settings for different purposes (Fua, 2009).

In research, *talanoa* is a tool for data collection and analysis involving a researcher and participant engaging in an unstructured conversation based on an idea as a starting point, rather than set interview questions (Fua, 2009). Different Tongan researchers have explored the types or levels of *talanoa*: Vaioleti (2011) described at least eight types; Manu'atu (2000b) determined four different levels of *talanoa*; this variation demonstrates the complexity and flexibility of *talanoa*. The differences relate to the type of interaction,

familiarity of participants, how the *talanoa* is structured (i.e., who can ask questions, if at all), and the topic of the *talanoa*. *Talanoa* also incorporates key Tongan principles such as *faka'apa'apa* (respect), which guide the researcher to ensure the strength and validity of stories told. Furthermore, as the participants *talanoa*, the researcher must *fanongo* (listen with intent), thereby acknowledging and understanding the nuances behind silences, and implied meaning (Fua, 2009; 2014). As I began to understand the intricacies of *talanoa*, I realised the importance of considering how the relationships that exist (or do not) between the individuals involved in a discussion, and the purpose of that discussion, influences the type of data that is collected.

Pacific methodologies - Teu Le Va and the Ethnic Interface Model.

Two education-focused methodologies with a broader Pacific lens guided and provided reasoning in this research: Teu Le Va and the Ethnic Interface model. Teu Le Va is an approach that aims for research collected on Pasifika education to inform policy to achieve success for Pasifika students in Aotearoa New Zealand. It indicates that for research to be transformative for Pasifika students, it is essential to value and maintain relationships. It also acknowledges the importance and contribution of the wider Pasifika community and the use of the collected knowledge to improve Pasifika success (Airini et al., 2010). Also, Pasifika learners are centralised in any research to ensure their voices and issues are heard, and those of their families and communities. The second approach, Samu's Ethnic Interface Model (2015), is a framework to understand Pasifika intra-ethnic diversity in schooling. This model acknowledges the variation within each Pasifika group resulting from factors such as socioeconomic status, place of birth and schooling, and the role they play in contributing to individual world views.

This research complemented the Tongan and Pacific approaches described above with aspects of critical realism, relationality, and the MSF to allow a holistic understanding of the context and students' narratives to emerge. This approach has allowed the acknowledgement of Pacific values, protocols, knowledge, and beliefs during data collection, analysis, and reflection. It also enabled a better understanding of what was being said and not said about science education in Aotearoa New Zealand, and Tonga. Explanations of how the Tongan and Pacific approaches influenced this research follow below.

Locating Tongan and Pasifika/Pacific methodologies in this research.

In this research, combining elements of multiple qualitative methodologies allowed the aspects that complemented the research questions and participants to be applied rather than choosing one and accepting its limitations. This conceptualisation process (or teu within the KRF), considers the purpose of the research and who will receive the findings (Fua, 2009). Different research frameworks have been used to consider the research questions; these frameworks have been ranked and arranged (toli) in a manner to understand the participants' stories best. Other aspects have been ranked and arranged, including the knowledges discussed (TSK and WMS) and placing importance on the location of education rather than a birthplace to analyse the data.

Although my knowledge of Tongan culture was limited when I began my doctoral studies, what I did know was that the stories I was hoping to collect and understand were Tongan stories. Therefore, prioritising Tongan specific methods, frameworks, and perspectives was essential, but I would need to learn about them along the way. I knew that my ways of knowing were different because of the western influences on my epistemology. Therefore, I needed to counter this by foregrounding Tongan ways of knowing and constructing knowledge, and I particularly resonated with the idea of co-constructing knowledge with my participants, a process that occurs during *talanoa* (Vaioleti, 2006).

Talanoa is described as a "personal encounter where people story their issues, their realities and aspirations [allowing] more *mo'oni* (pure, real, authentic) information to be available for Pacific research than data derived from other research methods" (Vaioleti, 2006, p. 21). This is important for this research because although there has been much research done on Pasifika student performance and underachievement, very little has changed in Pasifika student outcome. Perhaps as Vaioleti (2006, p. 21) suggests, "the information, stories, emotions and theorising made available by Talanoa will produce relevant knowledge and possibilities for addressing Pacific issues" (Vaioleti, 2006, p. 21). This is the intention of this research and explains why exploring the context of *talanoa* has been so important.

Teu Le Va highlights the importance of exploring the cultural complexity of different Pasifika groups. This research's focus on Tongan science learners aligns with key outcomes of Teu Le Va. It adds to the limited research on Tongan students, particularly around science, as

well as integrating Pasifika knowledge, perspective, and values such as collective ownership into the research (Airini et al., 2010). Furthermore, it is focused on the stories of successful students, shifting away from the typical analysis of Pasifika failure to inform how the education system can achieve success for Pasifika learners from successful Pasifika learners.

Samu's Ethnic Interface Model (2015) was useful because it examines the interaction of the factors that influence the Pasifika learner and the institutions where they are educated. It also emphasises the intra-cultural diversity of each Pasifika group, for example, for this research, place of birth (Tonga, Aotearoa New Zealand, or elsewhere), whether they speak Tongan, or whether they went to school in Aotearoa New Zealand or Tonga or both. Such a viewpoint aligns with the aim of this research to explore teaching and learning practices that encourage success for Tongan students and the goal of developing a framework to identify contributors to success for Tongan science learners.

Concluding comments

This chapter outlined the four theoretical frameworks that have underpinned this research relative to a *Manulua*-inspired model heavily informed by Hau'ofa's (1993) seminal essay, 'Sea of Islands'. All four frameworks have been used to consider the participants' stories and to re-consider the delivery of science education in Aotearoa New Zealand, and Tonga. Critical realism, positioned as 'Oceania as Environment', emphasises the importance of ontology, rejects universal claims to the truth and considers the world as a place that is stratified by time and space, where phenomena exist even if individuals do not experience them (Danermark et al., 2005). 'Engaging Oceanic Ways', demonstrates how an understanding of relationality as vā provides a lens with which to examine how science education is delivered, particularly how relationships are enacted in teaching and learning spaces. 'Oceanic Knowledge: Valuing and framing', values the MSF's explanation of how all knowledge, including scientific knowledge, is influenced by context and the culture of the context, whether that is in society, a science classroom, or a laboratory. This cultural context also influences how we view knowledge and boundaries around what is considered valuable knowledge, 'Charting Oceanic currents', providing the perfect platform to engage with Tongan and other Pacific methodologies to view the participants' stories in the following chapters.

Chapter Three – The storytellers and their stories

This chapter outlines the storytellers (i.e., participants), their selection, and how their stories were captured and analysed. The stories mentioned in the title refer to the use of *talanoa*, a qualitative approach that allows Pacific participants to "story their issues, their realities and aspirations" in a more authentic way (Vaioleti, 2006, p. 21). Although the research interviews were originally designed to follow a western format, the drive to chart Oceanic currents by drawing on Tongan and Pacific methodologies became more influential during the research journey. The foregrounding of Tongan ways of knowing and constructing knowledge became more prominent as I, in turn, increased my confidence and understanding. As the participants began to share their stories, the shift to *talanoa* rather than semi-structured interview questions enabled a shared process of story-telling, a co-construction of knowledge (Vaioleti, 2006). This chapter describes this shift in methodology, outlining the move to embrace an interrogation of Tongan data with Tongan knowledge systems (Fa'avae, 2019) and presents the ethical considerations and limitations of the research.

The participants

Individual semi-structured interviews collected in-depth narrative accounts of specific experiences of Tongan science learners in Aotearoa New Zealand and followed the three key themes of the research (refer to Appendix D for interview schedule). Interviewees had passed at least two Stage 1 tertiary (or first-year bachelor's level) study courses and were either current students or recent graduates (in the last three years). They were asked to identify what helped or hindered their engagement in science subjects, which aspects helped or hindered their enjoyment of and success in science subjects, and how different teaching and learning practices encouraged this. Each participant was also asked to define success, what they considered to be 'science', and explain their understanding and experience of Tongan (Indigenous) science knowledge during their secondary schooling and university science education.

Data saturation was achieved with twenty-six interviews when the participants were speaking to similar themes and not providing new information in their stories. The interviews

were all conducted using general open-ended questions in English according to the participants' preferences; yet, the responses were not exclusively in English. The participants were offered the option of English with the researcher or Tongan with a bilingual research assistant; all participants opted for English with the researcher. I am not Tongan and do not speak Tongan, potentially limiting the participants' use of Tongan phrases in an interview conducted in English. Yet, all participants were informed before their interview that they should tell their story their way. If that involved using the Tongan language, then it was possible to use another interviewer who spoke Tongan or confidential translation services that could interpret any narrative told in the Tongan language during an interview conducted in English. This option of an alternative interviewer also addressed any conflict or power imbalance, especially if the participant was a former student of mine who may have been unwilling to share negative stories of their teaching and learning experiences, especially if they involved naming other staff.

All participants consented for their interview to be audiotaped and transcribed by the researcher for data analysis. Any Tongan phrases and words were transcribed first in Tongan and then translated into English by the researcher. The interviews took one to two hours each, which allowed time to establish an appropriate relationship and cover all the areas of interest. They also considered Tongan cultural values and beliefs. Before any interviews began, the interviewer introduced themselves and outlined the research parameters to clarify the participant's expectations and the expectations placed on them. An interviewer must build rapport with the interviewee to ensure the validity of the data collected, reflecting the need to value and maintain relationships for research to be transformative for Pasifika students (Anae, 2010). This connection was prioritised by spending time at the beginning of the interview building connections, trust, and a rapport between the interviewer and the participant, by offering prayers before the interview and providing food (if appropriate) (Anae et al., 2001). The interviews closed with the interviewer thanking the participant for sharing their stories and their time and the presentation of a small koha (gift), acknowledging the Pasifika values of reciprocity, love, and respect (Anae et al., 2001).

As the Tongan community is so small, it was especially important to verify the confidentiality of the research process so that participants were comfortable to share their stories and understood the ways that processes, such as the consent form (see Appendix C),

and de-identifying the stories in published narratives, ensure they are not readily identifiable. Consultation and collaboration are an integral aspect of the research process when working with Pasifika and should occur at different stages, including analysis (Anae et al., 2001). To build trust and confidence in the research process, and ensure the integrity of the data collected, participants were able to view their interview data and highlight any aspects they did not want to be shared. This collaborative process helps with validity, reliability, and confidentiality in such an identifiable participant population, and encouraging the participants' involvement in determining which data is disseminated.

Participant Selection.

The research participants were selected using non-probability sampling. I chose this sampling technique because it does not require there to be an equal chance of selection; the aim of this project is not to represent the whole Tongan student population but understand the experiences of those students who have been successful. As outlined previously, there is a low level of success, retention, and achievement for Pasifika students in secondary and tertiary science. Therefore, I deliberately selected the participants for particular characteristics, i.e., successful science exposure, so they cannot be statistically representative of the Tongan population in Aotearoa New Zealand. This selection is important because the findings of the research are not intended to be generalised across the Tongan population. Instead, the narratives of these successful Tongan students may be used to inform teaching and learning practice so that there can be an increase in the overall number of Tongans students that are successfully engaged and achieving in science.

Purposive non-probability sampling was used to deliberately choose participants based on a set of criteria (criterion purposive sampling). The following eligibility criteria were used to select participants:

- Age: Must be 16 years of age or older
- Ethnicity: Self-identification as Tongan
- Secondary school education: Educated in either Aotearoa New Zealand or Tonga or both.
- University study: Current enrolment in a degree with a science focus, in either the Faculty of Science (majoring in biology, chemistry, physics and related courses), or in programmes offered by the Faculty of Medical and Health Sciences that have a science focus (i.e., Bachelor of Nursing, Bachelor of Pharmacy etc.) and have courses

focusing on biology, chemistry, physics, and related courses, or a recent graduate (up to three years) of any of these programmes.

- Science focus: Passed at least two Stage 1 science courses in biology, chemistry, physics, and related courses. (This excluded Tongan science learners who had not passed at least two Stage 1 courses in those subject areas).

As the research aimed to also explore the differences in gender and socialisation processes on engagement, enjoyment, and success in science, it used purposive sampling to ensure there was a mixture of characteristics (for example, gender, location of secondary school education) within the participant pool.

Altogether, 26 students were interviewed (16 females and ten males), all who self-identified as having Tongan ethnicity. The original eligibility criteria acknowledged the importance of identity by location of birth (i.e., whether students were born in Tonga or elsewhere, usually Aotearoa New Zealand); nevertheless, during the early stages of data collection it became apparent that where the individual's primary or secondary school experiences occurred was more meaningful to their narratives than where they were born. This distinction reflects research that indicates how early education experiences socialise students into the education system (i.e., Fleer, 2005). Of the sixteen female participants, eight were educated solely in Aotearoa New Zealand, seven were educated in Tonga for some, if not all, of their primary and secondary schooling, and one had experienced part of their education elsewhere in the Pacific. Of the ten male participants, six were educated solely in Aotearoa New Zealand, whereas four had experienced the Tongan education system at some stage of their primary or secondary schooling.

All participants had completed at least two consecutive years of study at the University of Auckland (ranging up to six years) and were enrolled in either a degree in the Faculty of Science (N=9), the Faculty of Medical and Health Sciences (FMHS) (N=16) or were a recent graduate of FMHS (N=1). All of them had passed at least two Stage 1 science courses in biology, chemistry, or physics with a passing grade. Seven participants began their university study in a bachelor's degree, whereas 19 completed one year of foundational studies at the University before beginning their programme of study (two of these were returning to university study via this pathway after pastoral issues meant they did not complete their first programme of study). Some of the participants met the entry criteria to begin their

bachelor's study but chose to do the foundation year for a range of reasons related to transitioning and subject exposure.

Students who had passed some university-level science study were the focus of my research to be able to understand what contributed to their educational success and retention in the tertiary sector (Coxon et al., 2002; Benseman et al., 2006). I acknowledge the contradiction of defining success using an institutional measure (pass vs. fail) to determine the eligibility of a group while trying to determine how these students have been successful in a system that continually fails most Pasifika students using institutional measures. This contradiction is addressed in subsequent chapters alongside an exploration of the participants' definitions of success.

As the number of Tongan students who take science in higher education in general, or specifically at the University of Auckland, is not large, maintaining the anonymity of the participants was paramount. I removed all readily identifiable demographic information such as place of birth, gender, school name (primary or secondary), teaching staff, family relationships, and experiences of tertiary study, programme, and year of study, and religion from any documented narrative. In general, participants' narratives are only identified by where their education took place (see below for a more detailed explanation).

Defining the two groups.

For the data analysis and reporting, I divided the participants' narratives into two groups: Kingdom of Tonga educated (KOTE) and Aotearoa New Zealand educated (ANZE). All of the KOTE participants (N=13) were educated in Tonga during their primary schooling (defined in this research as the first six years of education), with most migrating to Aotearoa New Zealand sometime during their secondary school education (Years 8-13) while two participants completed their entire secondary schooling in Tonga before migrating to Aotearoa New Zealand for university. There were two exceptions: the participant who was educated in the Pacific (Tonga and elsewhere), before migrating to Aotearoa New Zealand for secondary school; and the participant who migrated from Aotearoa New Zealand to Tonga for their secondary schooling before returning to Aotearoa New Zealand for university. They were included in the 'KOTE' group because the education system they were socialised into during their early education experience is more like the Tongan system than the Aotearoa

New Zealand system. Furthermore, classifying them on their own would make the stories they tell too identifiable. The second group, ANZE (N= 13), are those participants who completed all their primary and secondary schooling in Aotearoa New Zealand, before continuing to university.

The heterogeneity of the sample acknowledges the reality of the Tongan educational experience and meant participants narrated a variety of individual experiences, capturing some of the diversity apparent within the Tongan population in Aotearoa New Zealand. It also allowed a comparison of the teaching and learning practices between Tonga and Aotearoa New Zealand, discussed in subsequent chapters. Furthermore, the mix of genders allowed the possibility of exploring factors contributing to the differential success of Pasifika boys and girls in education (Statistics New Zealand and Ministry of Pacific Island Affairs, 2010).

Family experience of tertiary study.

Although most participants had immediate or extended family who had experienced some form of tertiary study (either at a polytechnic or university), four were the first in their families to be attending university. More interesting is the educational attainment of the participants' parents, which is atypical for both Aotearoa New Zealand and Tonga: 17 of the 26 participants had either one or both of their parents attend university either in Aotearoa New Zealand, Australia, Tonga or elsewhere in the Pacific[27]. The level of parental educational attainment was quite different for the two participant groups: twelve of the thirteen KOTE participants have one or more parent with a university degree (ranging from bachelor's level to PhD); while six of the 13 ANZE participants have one or more parent with a university degree (ranging from bachelor's to master's degree level) and four had one or more parent who had completed tertiary studies.

Decile rating.

Decile rankings are frequently used as measures in literature and popular media discussing Aotearoa New Zealand's educational system, often as a proxy for school quality, although some researchers suggest that they ignore the specific school context when

[27] Most of these parents completed this education before they had children; however, some have completed their degrees more recently.

attempting to use them to measure school performance (for example, Thrupp & Alcorn, 2010). Although decile rating is a complex and contentious measure, the debate about its use to measure and compare schools is beyond the scope of this research. Nonetheless, it is interesting to look at the decile ranking of the schools these successful students attended. Particularly when looking at programme of study and subject choice, it seems to add weight to the argument that it is aspects of individual schools, such as their organisational culture, that influence student performance rather than a decile ranking. Furthermore, as a small number of participants commented directly on decile ranking, it was necessary to acknowledge it.

Twenty-three of the participants attended at least one secondary school in Aotearoa New Zealand for a minimum of two years: nine of these attended a low decile secondary school (decile rating 1-3); seven attended a mid decile secondary school (decile rating 4-7); seven attended a high decile secondary school (decile rating 8-10). This decile range was pleasing as it contributes to the diversity of participants' experiences. Also, three participants changed secondary schools within Aotearoa New Zealand, for various reasons. They were able to share their perspectives on their experience of two different organisational (secondary school) cultures and the differences and similarities that existed in them.

'Science' subject definition and exposure.

A science subject is defined in this research as a course focused on biology, chemistry, and/or physics, and their various alternatives, as they are the traditional science subjects at secondary school. This definition created a link between the secondary and university science programmes and allowed comparisons between teaching and learning methods and approaches in both.

Most (N=20) of the research participants took all three sciences during their secondary schooling. This subject selection is unusual as reflected in the many stories where participants found themselves the only Pacific student in their science classes. Five participants took biology and chemistry, and one took biology only. Physics is the subject that participants were less likely to have taken due to issues around availability, class scheduling, or perceived difficulty. Different issues were apparent for the two different groups: for the KOTE participants, it was more common for them not to take physics because it was not

offered in Tonga, whereas the ANZE participants either did not take physics because it was not offered, or they stopped taking it because it was too hard.

To fully locate these participants, I analysed the contemporary (2015) data on subjects taken in Aotearoa New Zealand's secondary schools. These data were used because the participants left secondary school between two and seven years ago, meaning there is no specific year that is directly relevant and because the data from 2015 tell the most current story of science education in Aotearoa New Zealand.

In 2015, biology was the most popular of the three 'hard' science subjects in Aotearoa New Zealand's secondary schools (N=34,147), compared with chemistry (N=29,286) and physics (N=28,417) (Education Counts, 2016). Analysing the same data set by gender and decile rating raised some interesting observations. Gender was correlated with science subjects taken in Year 11-13 in 2015 in the following ways: twice as many female students took biology as males; similar numbers of male and female students took chemistry; twice as many males took physics in Year 11-13 as did females. Decile ranking was also correlated with the science subjects taken; the higher the school decile ranking, the higher the number of students taking science. Furthermore, fewer students took these subjects in Year 13 regardless of decile ranking or gender than in Year 12. These observations all suggest that the participants in this research are unusual, not only because they are successful in an educational climate where Pasifika students are chronically underachieving but because most had taken all three sciences until Year 13, regardless of their school decile ranking or gender.

The participants as storytellers.

The initial planning around data collection was very much considered within the western framing of the ethics process, meaning a semi-structured interview question format. But, to realise the influence of *talanoa*, it required the acknowledgement of critical aspects such as *faka'apa'apa*, *fanongo,* and *tauhi vā* during the interview process. This tension meant interviews were conducted within the bounds of the structure of the ethics, but also prioritised time spent creating the relational space between the participant and the interviewer. The interviews also emphasised the importance of the participants speaking freely about their concerns, interests, or issues; frequently, they became occasions for sharing of advice, guidance, and career counselling.

The style of data collection aligns most closely with Vaioleti's (2011) *talanoa faka'eke'eke. 'Eke* implies asking a question, allowing a participant of the *talanoa* to drive the questioning to uncover particular knowledge. I had known most of the participants for several years before the formal interview; some have stayed in contact since. For the interviewees who did not know me, many were referred by someone else who did know them, demonstrating the importance of connectedness (another aspect of relationality). Only one participant had no prior connection (they responded to the research advertisement; see Appendix A). In this interview, the participant spoke freely, particularly about the racism they had experienced and the disillusionment they felt about their prospects in science as a result. These were similar topics of discussion to the other participants.

Most of the interviews provoked an emotional response, as many of the shared stories described very negative experiences. Emphasising Fua's (2014) general principles of *faka'apa'apa* (respect), *loto fakatōkilalo* (humility), *fe'ofa'aki* (love, compassion) and *feveitoka'i'aki* (caring, generosity) during the interviews for this research enabled deeper, more honest and authentic conversations than by employing strictly western approaches to a research interview.

As described above, the unscripted nature of a *talanoa* often conflicts with the ethics committee expectations, making it a challenging methodology. Fa'avae, Jones, and Manu'atu (2016) suggest that *talanoa* is about making connections, so information is shared and that the difficulties of using *talanoa* should be discussed explicitly as new researchers will find it challenging. Although I did not set out to use *talanoa* as a method, it influenced my methodology from the start through the embodiment of *faka'apa'apa* and the importance placed on *fanongo* (Fua, 2009; 2014), both previously described in Chapter Two. In practice, the semi-structured interview format would often by superseded by *talanoa* at different points during the interview; in most of the interviews, *talanoa* often became the dominant form of interaction when the semi-structured questions become redundant. This change was evident when the participant began to direct the conversation more than I did; they took the opportunity to share instead what concerned them more than what I (initially thought I) wanted to know (Vaioleti, 2006).

Protecting the storytellers: Ethical considerations

A researcher must address any ethical issues, concerns, or conflicts before they begin their research and ensure there is a balance between the value of gaining new knowledge while protecting the rights and privacy of the participants (Neuman, 2011). It is important to ensure any participants are giving informed consent and that the researcher maintains the anonymity, confidentiality, and cultural safety of their participants throughout the research process[28].

Informed consent.

To ensure participants were fully informed and participating voluntarily they were provided with a participant information sheet (PIS) (see Appendix B) and consent form that provided a clear and comprehensive overview of the purpose and benefits of the research, requirements of the participants and their rights, and how the data will be used. These forms outlined the way key ethical issues such as confidentiality, anonymity, data collection and storage, cultural sensitivity, and withdrawal from the project were managed.

Anonymity and confidentiality.

It is paramount that the privacy of the participant is protected, keeping their identity confidential and their contribution anonymous (Cohen, Marion & Morrison, 2011). As the Pasifika participant pool can be small and, therefore, easily identifiable, it is especially important to maintain confidentiality (Anae et al., 2001). Therefore, participants were identified only by whether they were educated in Tonga or Aotearoa New Zealand.

As the participants were chosen from a small potentially identifiable pool, there is the potential for participants to be identified by the stories they tell regarding their experiences of a course or a teacher-participant interaction or other recognisable participant experiences even if the information is de-identified. Therefore, it is important to stress how any concerns about participant safety will be addressed other than the standard practice of de-identifying data and maintaining confidentiality outlined elsewhere. Primarily, I was a part-time student meaning the data collection, analysis, and dissemination took a reasonable amount of time (i.e., five years). Therefore, by the time the data becomes published, it is possible to assume

[28] The University of Auckland Human Participants Ethics Committee approved this research on 08/04/2015 for three years, Reference number 014009.

that most of the participants will no longer be undergraduate students, addressing any concerns regarding the institutional memory that may otherwise have had the potential to affect a participant's academic progress. Furthermore, my supervisors had oversight of the data analysis and reporting, preventing the dissemination of identifying details.

Cultural considerations.

When working with Pasifika, it is important to address any concerns around social and cultural sensitivity. This research achieved this in the following ways: the participants had the option to be interviewed in their first language; I consulted with experts to ensure I used appropriate cultural practices and protocols; my supervision included Pasifika and Pacific expertise.

Withdrawal of participation.

As participation was voluntary, participants were able to withdraw from the individual interview, or not to be audio recorded, as stated in the PIS and consent form (CF). It was emphasised that such a decision would not affect their teaching and learning experience at the University of Auckland, the grades they would receive, nor the support they would receive from academic and professional staff.

The stories: Framing the analysis

The process of analysis enables the researcher to organise, integrate and examine data so that they can find patterns and relationships, connect data to concepts, identify themes or trends and improve understanding and advance knowledge (Neuman, 2011). Data were thematically analysed using a retroductive approach. This approach encourages a tautological process that continuously switches back and forth between the consideration of the data and theory to find meaning (Ragin & Amoroso, 2011). Retroduction is not a formalised mode of inference like deduction or induction, nor does it follow formal logic or strict logical inference (Danermark et al., 2002). According to Danermark et al. (2002), deduction looks for logical conclusions based on the initial premise but does not add anything new to reality while induction seeks the common element that might be extrapolated to a larger population but is restricted to conclusions in the empirical realm. By contrast, retroduction considers structures and mechanisms that are not observed in the empirical domain to ask, "what qualities must exist for something to be possible?" (Danermark et al., 2002, p. 80). The

absence of fixed criteria limits the ability of retroduction to test its validity definitively. However, the ability for abstraction rather than logical reasoning means retroduction can offer a broader consideration. For example, if we are interested in what 'X' is, deduction finds assumptions about X, induction creates generalisations about X, but retroduction considers "What properties must exist for X to exist and to be what X is? …. What makes X possible?" (Danermark et al., 2002, p. 97)

Tongan research methods mentioned previously, the KRF and *talanoa*, also influenced the data analysis. During the early stages of analysis, independent coding and coding-consistency checks were undertaken to ensure the trustworthiness of analysis. The influence of the *talanoa* methodology extended to the data analysis, particularly the acknowledgement of silence. While participants' *talanoa*, researchers must *fanongo* (listen with intent) to understand the nuances behind the silences and interpret their implied meaning (Fua, 2009). The categories and themes, and the frequency of responses within and between these, enabled me to review the categories and themes by demonstrating patterns within the analysis (Shenton & Dixon, 2004). Moreover, key aspects of the participants' narratives have been reported directly using their phrases and sentences to maintain the integrity of their stories (Cohen et al., 2011).

Reliability/Validity.

It is important to determine the value of the data collected and the usefulness and reliability of the data analysis and subsequent findings. Traditionally quantitative and qualitative researchers have measured this in terms of objectivity, validity, and reliability, where validity measures how accurately the participants' voices are represented, and reliability determines whether the data is internally and externally consistent (Neuman, 2011). Nevertheless, some researchers argue that measuring the trustworthiness of the research findings is more appropriate for qualitative research. Guba (1981) suggests credibility, transferability, dependability, and confirmability can be used to determine how trustworthy the research is: credibility and transferability are preferable to validity; dependability replaces reliability; and confirmability is measured in place of objectivity.

According to 'Otunuku (2011), *talanoa* has high validity as a form of data analysis because the data collected is in-depth, but it has 'low reliability' because the time-consuming

nature of the method means only small numbers are studied. Vaioleti (2006) argues that *talanoa* produces 'authentic knowledge' and that trying to apply the concepts of validity and reliability is problematic because the viewpoints of the participants are situated within the time and context (*tā* and *vā*) of the interview. As the participants might change their views if the *tā* and *vā* changed, reliability is not an applicable concept. Instead, the trustworthiness and relevance of the data collected for analysis should be considered (Vaioleti, 2006) using Guba's (1981) four measures as outlined below.

Transferability.

Transferability is concerned with the extent to which the research findings can apply to another context or population. Yet, as most qualitative research focuses on a group or population in a specific context or situation, it is often not possible to be sure from the outset exactly how useful the findings will be to another setting or population (Shenton, 2004). This creates a somewhat paradoxical situation: how do you balance the importance of contextual factors in making the research significant while also allowing it to be generalisable. One way to assist with determining transferability is to provide a thick description (Shenton, 2004). Thick description allows an understanding of the research findings in context and, in this research, will involve the description of key players such as the participants (place of birth, gender), the education setting (secondary or university), the location of the secondary school education (i.e., Tonga, Aotearoa New Zealand, or elsewhere) the pedagogy used, the subject studied (i.e., biology, chemistry, physics or their various alternatives). This explanation of the research context allows the reader to determine the similarities in the 'sending' context (i.e., the context of the analysed data) to decide how and if it is transferable to the 'receiving' context (i.e., the context that the reader is interested in) (Shenton & Hay-Gibson, 2009). It can also add understanding, or 'illuminate', why particular sampling decisions were made.

Dependability.

Where positivists use reliability to look for replication of the data, dependability is a more significant measure for qualitative research because it looks at how 'stable' the results are from the research analysis (Guba, 1981; Shenton, 2004). In other words, rather than testing if the same results would be achieved if the research was repeated (i.e., same context, same methods, same participants), dependability determines the consistency of the

interpretation of the collected data (Shenton, 2004). Dependability was achieved in this research through the establishment of an auditing process, in the form of an audit trail documenting how the research processes are undertaken (i.e., notes taken during interviews) and allowing an external auditor to see how the data was collected, analysed and interpreted. Reporting specific experiences strengthens the 'audit trail' and increases trustworthiness (Shenton & Dixon, 2004).

Credibility.

Credibility is defined as the confidence the researcher has in how 'truthful' their findings are and is key to trustworthiness. The validation of findings can involve various methods, including triangulating types of data or methods of collection, member checking (Creswell, 2012), or debriefing with peers or supervisors (Shenton, 2004). Triangulation involves the use of different methods (i.e., individual interviews and focus groups) to cover the limitations of using one method, usually regarding data collection. Yet, in this research, triangulation occurred at multiple points, data collection, and analysis, with the use of Tongan and western methods of data gathering and interpretation.

The KRF articulates the analogy of how the process of making *kakala* (garlands) can symbolise a Tongan approach to research. Where an outsider might view the process of making *kakala* as 'disorganised and chaotic', it is a process that has direction and purpose with a defined recipient or endpoint (Fua, 2014). However, when making *kakala*, it is common to have to gather more flowers to complete a pattern or to change the pattern if there are not enough flowers available. This process of negotiation and correction mimics the process of negotiation and readjustment that the analysis of data often requires (Fua, 2014) and reflects the methodological positioning of this research to embrace both Tongan (or Pasifika) and western approaches.

Member checking involves several participants checking the accuracy of the analysis; this occurred when the participants were sent a copy of their interview transcript for checking and commenting on (Shenton, 2004). Peer debriefing was used to check the 'tentative' categories determined by early analysis for validity, reliability, and trustworthiness; my academic supervisors acted as 'critical friends', provided oversight of the data analysis, questioning, challenging, and critiquing to determine credibility by maintaining

an objective lens on the data (Fua, 2014; Shenton, 2004). The use of the supervisors as 'critical friends' mirrored the negotiation and correction between women when making *kakala* described by Fua (2014) as the "communal process that demonstrates collaboration, sharing of resources and the passing of skills to the next generation" (p. 50).

Confirmability.

The final measure of trustworthiness is confirmability. Confirmability aims to determine how much the research findings reflect the participants' voices rather than the researcher's predilections (Guba, 1981). Confirmability is established with the use of reflexivity and auditing, as well as triangulation discussed previously relative to credibility. Reflexivity asks the researcher to consider, discuss, and document their inherent biases, motivation, and interests alongside their findings and how their position may have changed throughout the research process. In my ethics application, I began this process by outlining my focus on foregrounding the needs of Pasifika students in their teaching and learning, and a non-victim blaming approach that values the lived experience and student voice of Pasifika students, and by describing my positionality.

Credibility can also be achieved using a 'confirmability' audit, which certifies that "data exist in support of every interpretation and that the interpretations have been made in ways consistent with the available data" (Guba, 1981, p. 88). This was achieved using the supervisors and other doctoral students who acted as 'critical friends' to test the categorisation and theming.

Key assumptions and limitations

Even though the number of Tongan university students is small, the number of Tongan science learners at the University of Auckland is even smaller; I was able to recruit enough participants that meet the eligibility criteria to share their stories. When weaving *kakala* the flowers and leaves must be sorted, grouped and arranged; analysis also sorts, groups and arranges to look for "similarities, variations and new emerging patterns" in the data (Fua, 2014, p. 54). By the time I had arranged and sorted the first 20 participants' stories, I saw considerable similarities and overlap. Nonetheless, I continued interviewing until I reached a total of 26 participants to ensure there were no new insights or patterns but also to enable

those who had expressed interest in the research to tell their stories rather than exclude them from the opportunity.

As they had to be 'educationally successful' the participants are not representative of all Tongan students (Anae, 2010); but the range of selection criteria characteristics (i.e., gender, location of birth, location of secondary school education) of recruited participants are representative of the intra-ethnic diversity of the Tongan population in Aotearoa New Zealand. This enabled the capturing of differences such as socioeconomic position, helping to expand the understanding of the parameters of 'Pacific' demography (Anae, 2010) that may be contributing to success. The retrospective reflection of participants on their secondary schooling experiences may also appear to be a limitation because of the time since they were in secondary school. However, the participants were able to recount their stories in their voice, enabling them to self-disclose their version of the truth, which is influenced by their experiences and emotions and is their truth (Cohen et al., 2011)

I feel my (somewhat limited) cultural competence in the interview setting encouraged my participants to share their stories with me, but primarily their willingness was influenced by my 'social identity' (Fa'avae et al., 2016), that of a Tongan mum. I have learnt to be a mum during my doctoral studies; I became pregnant with my first child the same month that I officially enrolled as a student; I now have two. They guide and inform everything that I do, as does my husband with whom I truly *pō talanoa*. We discuss my studies every night. I seek his feedback, guidance, and advice, he seeks feedback, guidance, and advice from his parents who live with us, they discuss my questions with others in their communities; this research represents a collective effort.

I am also very aware that as a *Pāpālangi* researcher, I could interpret my data with my biases informed by my overt (and covert) ideological frameworks (Smith, 1992 in Vaioleti 2006, p. 23) and present data that misrepresented my participants. Informed by the focus of *tui* in the construction of *kakala*, I carefully considered the importance of how I sorted, grouped, and arranged my data so that I was not distorting, hiding, exaggerating, or overlooking what my participants had shared. I was also very conscious of the *fanongo*, the silences, which occurred many times in each interview, usually around similar, negative topics, such as teachers, racism, micro-aggressions, and so on. To assist with the process of

'constructing' my *kakala*, I engaged in *pō talanoa* with my husband and numerous discussions with my supervisors and other Pasifika/Pacific doctoral students, to determine if my *Pāpālangi* lens was interpreting things differently than what the Tongan science learners I had spoken with were saying. This reflective and retroductive process also aligns well with the discussions that occur during the making of *kakala*, where women work collectively together to achieve a beautiful *kakala*, one that is worth gifting.

Concluding comments

This chapter has outlined the research methods and how the different Tongan and Pacific methodologies have informed the data collection and analysis. Although the participants come from diverse backgrounds and have had different academic journeys, they share Tongan ancestry. Together they demonstrate the demographic heterogeneity of the Tongan diaspora in Aotearoa New Zealand, providing valuable perspectives with which to enable a deeper understanding of the Tongan science learner experience in Aotearoa New Zealand. The next chapter shares some of their stories about engagement, enjoyment, and success.

Chapter Four – Sharing their stories: Engagement, enjoyment and success in science

This research aimed to locate successful Tongan science learners relative to engagement, enjoyment, and success. In this chapter, I will share my participants' definitions, experiences, and opinions about engagement, enjoyment, and success in secondary and university science education in Aotearoa New Zealand, and for some, their schooling in Tonga. They are core ideas in education and need some consideration before presenting the rest of the findings in the following chapters. This chapter also offers some of the participants' suggestions on how to consider engagement, enjoyment, and success in science learning spaces.

Why engagement, enjoyment, and success?

My interest in investigating predictors of engagement and success in science subjects for successful Tongan science learners[29] stems from their prominence in education discussions, research, and policy, both locally and globally. Although not as prominent, the concept of enjoyment in science education interests me because I believe it is important to understand and consider how enjoyment relates to science education for Tongan science learners. It is also essential to understand what Tongan science leaners consider enjoyment to be in science education and whether science educators have an accurate understanding of what enjoyment is or if they are imposing another viewpoint of how enjoyment is manifested or presented.

Despite the importance of these terms in education, little is known about how successful Tongan science learners define engagement, enjoyment, or success', and which teaching and learning experiences have enhanced or detracted their engagement, enjoyment, and, and success during their science learner journey. Since the published definitions of these three terms can be highly variable, having a Tongan perspective is useful for the consideration of educators, policymakers and researchers working in Aotearoa New

[29] The initial research focus was on achievement, engagement, enjoyment, retention, and success. However, to manage the scope of this thesis, achievement and retention are not considered here.

Zealand's education system, to consider how the country's education policy and practice to address the underachievement of Tongan (and other Pasifika) science learners.

Numerous academics have argued that the inclusion and acknowledgement of Tongan values, knowledge, and identity will improve Tongan students' experiences in Aotearoa New Zealand. As a science educator, I am particularly interested in Manu'atu's (2000) suggestion that incorporating Tongan concepts such as *mālie* and *māfana* in the teaching of science could transform the staid atmosphere of the usual science classroom to one that energises Tongan students to learn. *Mālie* is something done well, a form of positive feedback, or recognition of skill, and *māfana* is a process of becoming impassioned, emotionally moved. Manu'atu (2000) argues that together, these two concepts are transformative, allowing the possible to occur out of the impossible. I suggest that engagement, enjoyment, and success are all aspects of *māfana*. Therefore, to be able to transform science education so "learning takes place and prospers" ('Otunuku, 2010, p. 27), it is necessary to understand how Tongan science learners define them.

As previously indicated, this research intends to use successful Tongan students' stories to explore new ways to address Pasifika underachievement. The power of the collective story is the ability to create new narratives and transform the standard 'cultural plot' (Richardson, 1990). Rather than the constant presentation of Pasifika student failure, this research will tell the story of those students who have experienced success, so as to 'dehegemonise' (Nabobo-Baba, 2006) how Tongan (and Pasifika) student success is understood or described. The aim is to provide a new narrative that may encourage other Pasifika students to engage and succeed in science. Furthermore, the themes developed during the analysis can be used to direct future initiatives or practice, such as the development of teaching and learning approaches that drive Tongan success in science. The emphasis placed on the individual's experience means they could tell their story and describe their experiences and feelings, giving authenticity and representation to the Tongan student voice (Bishop, 2003).

During the interviews for this research, all participants were asked to consider and define each term and then describe ways teaching staff could identify engagement and enjoyment and how experiences of engagement, enjoyment, and success had been helped or hindered at secondary school and university. They also indicated which types of teaching and

learning delivery contributed to their engagement, enjoyment, and success when learning science. This chapter presents the participants' definitions of each term in turn, first locating the term within the recent literature and then sharing their experiences and reflections on engagement, enjoyment, and success. The two groups are differentiated by KOTE and ANZE only if there were distinct differences in their responses. The participants' responses regarding engagement, enjoyment, and success are woven early into this document to create a platform from which to explore the rest of their stories and experiences regarding their secondary and university science education.

Engagement

Engagement is a term often cited in research as an important factor in education for learning and achievement but is often not categorically defined. This is understandable given it is a complex term covering a diverse range of perspectives, which may or may not be mutually exclusive. It has been a topic of research for the last few decades but has become an increasing focus of educational and government strategies as "engaged students are more likely to persist, achieve success and complete qualifications" (Kuh, Kinzie, Buckley, Bridges, & Hayek, 2006 cited in Leach & Zepke, 2011, p. 193). Researchers consistently agree that engagement is important for student learning and achievement, yet, "there is debate over the exact nature of the construct; a key problem is a lack of distinction between the state of engagement, its antecedents and its consequences" (Kahu, 2013, p. 758). Some researchers argue that engagement relates to the amount of time and energy a student puts into their learning (Chapman, 2003; Kuh, 2004 cited in Leach & Zepke, 2011, p. 193) while others, such as the Australian Council of Educational Research (ACER) (2008) define engagement as "students' involvement with activities and conditions likely to generate high quality learning" (p. *vi* cited in Leach & Zepke, 2011, p. 193). Other indicators can include students' "morale, perceptions about school, participation in decision-making, attitudes and behaviour" (Education Review Office, 2010, p. 12).

Moving beyond definitions that focus on what the student is doing, it is important to acknowledge the contributors to student engagement. Fredericks, Blumenfield and Paris (2004) argue that attempting to conceptualise engagement by isolating the specific aspects within the term is problematic, and creates "a proliferation of constructs, definitions, and

measures of concepts that differ slightly, thereby doing little to improve conceptual clarity" (p. 60). Instead, they suggest that researchers acknowledge the multifaceted nature of engagement and consider it as a 'meta' construct that covers a wide range of factors. A recent synthesis of research on engagement by Kahu (2013) identified four (overlapping) approaches to defining engagement:

> the Behavioural perspective, which focuses on effective teaching practice; the Psychological perspective, which views engagement as an internal individual process; the Socio-cultural perspective, which considers the critical role of socio-cultural context; and finally a Holistic perspective, which strives to draw the strands together (p. 758).

She notes that early research often defined engagement as relating to isolated aspects such as behaviour and cognition, whereas later work suggests a combined approach acknowledging "[e]ngagement is fundamentally situational – it arises from the interplay of context and individual" (p. 763).

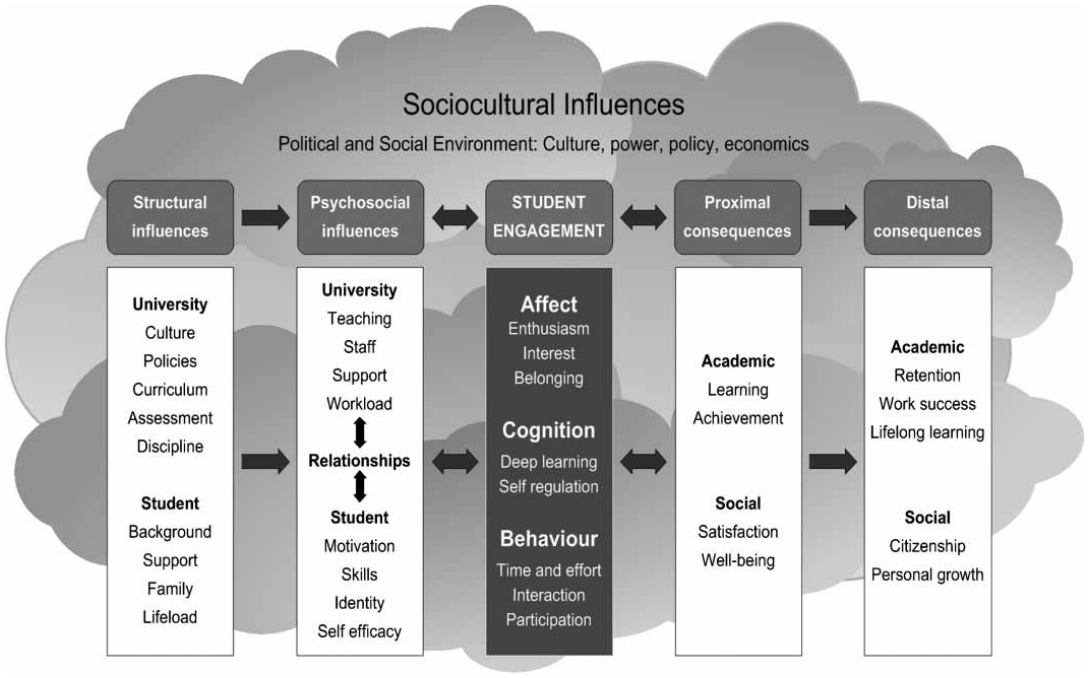


Figure 5: Conceptual framework of engagement, antecedents and consequences. Retrieved from Kahu (2013, p. 766).

Kahu (2013) argues that all four perspectives are limited by their definitions, categorisation of variables, scope, and in some cases, such as the behavioural and

psychological, the methodology used. Thus, she has developed her conceptual framework on engagement (see Figure 5) that includes antecedents and consequences. It is also embedded in the wider socio-cultural context so that it identifies the multiple players (the student, teaching staff, the institution, and the government) who are responsible for improving student engagement. It is important to acknowledge the socio-cultural context because minority students can often feel 'othered' or deficient in an educational institution's culture because of the inherent social and cultural bias that favours the dominant social groups (Lawrence, 2006, cited in Kahu, 2013). Not having the same social, cultural, and academic capital can often lead to disengagement or poor retention of minority students. Yet, this frames deficit thinking towards the students, rather than acknowledging that disengagement (or declining engagement) could be the result of generational differences around expectations and aspirations, and societal changes in education such as the market-driven tertiary system, that the institutions themselves need to address (McInnis, 2001).

A key strength of Kahu's framework is that it acknowledges the complexity of engagement described in the four perspectives above as well as highlighting that multiple factors are at play at any one time, can affect each other and can be addressed to improve student engagement. It recognises the traditional focus on engagement such as the type of services (teaching and support) under institutional control, but also aims to increase "student awareness of the range of variables within their own control, and the potential impact these factors have on their engagement and success at university" (Kahu, 2013, p. 767). This framework views engagement as "a psycho-social process, influenced by institutional and personal factors, and embedded within a wider social context, [that] integrates the sociocultural perspective with the psychological and behavioural views" (Kahu, 2013, p. 768) and will be the basis for considering engagement in this research.

Pasifika science engagement.

Kahu's framework acknowledges the unique individual experience and emphasises the need to study specific student populations to avoid broad generalisations. While there is some evidence for how to engage Indigenous and minority science students both internationally (for example, Aikenhead, 2006; Britner, 2002), and nationally (for example, Cowie, Jones & Otrel-Cass, 2010), little is known about how to engage Tongan science learners so that they are successful in Aotearoa New Zealand. It is reasonable to argue that

the better the understanding of engagement and its influencers for Tongan students, the more prepared educators will be to meet Tongan student needs, improve their educational outcomes and enhance their teaching and learning experience.

Tongan science learners' definitions of engagement.

Definitions of engagement usually focus on individual factors such as the amount of time and effort a student applies to a task (for example, Chapman, 2003). Nevertheless, some, including most of this research's participants' definitions, consider the interaction of multiple aspects that make engagement a 'meta' construct (Fredericks et al., 2004). The KOTE participants defined engagement in science as the passion for learning the content. For example, *"being engaged in science is wanting to discover or find out or attain information that you have always wanted to know about understanding the world, understanding people" (Katinia KOTE)*. It was also the desire to share knowledge: "*For me, engagement in science is using scientific knowledge. When we study chemistry, to explain to my little cousin when it reacts to that, it creates this... it's being able to explain to people how science works" (Fatai, KOTE).*

The ANZE participants defined engagement as being actively involved in the learning process: "*Engagement, [is] going to class, actively listening, not being on Facebook during lectures. I would define it as being active in your studies, in the teaching time, approaching the lecturers, or asking tutors for help or clarification (Lashandra, ANZE).* The overwhelming majority of participants in both groups felt that the primary indicator of engagement was students asking questions: *"One of the biggest things for me would be if I am asking questions. If I am asking questions it obviously shows that I want to learn, that I want to understand"(Katinia, KOTE).*

Overall, the participants' definitions reflect Kahu's (2013) multifaceted engagement framework described above, namely student behaviour and the 'effect' of engagement, as well as antecedents and consequences of student engagement. Most participants identified the relationship between the student and the teaching staff as a critical antecedent of their engagement:

> *Engagement is when there's talanoa going on between two people, or a group of people and a tutor. I know that's very difficult in a lecture setting [but] I know that*

I get distracted easily and if the lecturer isn't talking to me, and if I am not getting what he is trying to say, and I am trying hard to understand what he is saying, but it's not getting to me, I will doze off (Grace, KOTE).

Proximal consequences, those aspects that have a direct relationship with student engagement such as achievement and well-being were evident in the desire to learn more:

It's wanting to do it, giving it your all, engagement in science. That's what I think; you want to do it. Wanting to learn more, you think outside the scope of what they teach in lectures and apply [it] to other things (Takai, ANZE).

Narratives that outlined the relevance of science for lifelong learning and personal growth reflect the distal consequences, those that have a longer-term impact on contributing to society, such as work success and lifelong learning:

It's having an interest in science, and with interest comes passion... everything revolves around science, so if you love science, you are going to want to know more. Science is fascinating. You can't understand life if you don't understand science... you don't understand how your body works or how everything works. If you are not interested in science, you are not interested in life (Naua, KOTE).

The participants described the complexity of engagement and the interplay of multiple factors as well as ways to improve student engagement indicated by Kahu's model, particularly the contribution made by students and teachers:

Lashandra: if the students [are] willingly participating in activities, that's an indicator… also going around to the students, like with Team Based Learning[30]… that gives the perfect opportunity for the tutor to go around and give feedback. If teachers go around and talk to them and they have questions [then] teachers can engage with them and answer it in a way that they can understand it. You can tell if the way you have engaged with them is helping them or not.

SF: By talking to them?

Lashandra: Yeah.

Teaching staff demonstrating their interest in their students' understanding and academic outcomes is another way to help:

A big thing is having teachers or lecturers, tutors, who are interested in your learning, your results. A lot of my high school teachers, when I didn't do well in a

[30] Team Based Learning is a collaborative learning approach developed by Larry Michaelson in the 1970s. The learning strategy involves students working in teams over a semester to complete assessments together.

> *test, they would give constructive feedback. Sometimes they would offer to give a tutorial after class to go through it… that was helpful… knowing that the people that are teaching are interested or care about your grades and what you are learning is a big factor in making you engage (Jake, ANZE).*

Kahu's model is an appropriate vehicle for understanding these participants' responses because it recognises that aspects of engagement are under institutional control but also that the students can enhance their engagement and success at university: "*The lecturer stands up and does his lecture, and we watch. I know that can be hard for some people but my theory, my philosophy, is that you need to do the work, you can't complain, just do it" (Vaka, ANZE).*

Kahu's framework also acknowledges the unique individual experience and emphasises the need to study specific student populations to avoid broad generalisations. Although most aspects of the participants' definitions fit well within Kahu's model, some anomalies reflect the heterogeneity of the Tongan student population. Two highly achieving ANZE participants indicated that their behaviour could appear as disengaged even though they were engaged:

> *Probably test results, or with some students, the more questions they ask reflects how interested they are. But for me, throughout med school I wouldn't ask that many questions. I remember some tutors would approach me, 'Do I need help with anything?'. I would get it, but I wouldn't be vocal about it (Kava, ANZE).*

How the participants engaged in science at secondary school differed from at university. Although finding the content interesting and enjoyable helped some, most participants indicated that it was their career goal that drove their engagement: "*at secondary school, I wasn't engaged… I knew I had to do it, so I could get into what I wanted to be" (Sina, ANZE).* Most participants indicated that secondary school teaching staff had hindered their engagement: "*the teachers didn't teach us well, I didn't get most of the stuff they said, so that made it hard for me to try and get good marks" (Fifita, ANZE)*.

At university, interest in and enjoyment of the content helped with engagement, as well as peer pressure and the desire to complete their degree:

> *[Engagement] at uni is different from school. It's more that you want to finish your degree, you don't want to fail, you are surrounded by mates that want to pass, and that is all you talk about every day, and you don't want to let yourself down (Naua, KOTE).*

Although some university teaching staff hindered engagement, the different learning environment, resources, and style of delivery helped engage some participants who had been disengaged at school: "*the different lecturers' style… and the labs, I found that a better and an easier way, to engage with the information and what we were doing [than school]" (Avila, ANZE).*

Considering engagement for teaching and learning.

In terms of aspects of teaching and learning that impacted on engagement, most participants identified features of active learning as important. For example, most participants reported an excellent way to engage students was by making teaching interactive:

> *In school, when they get us to be interactive, they ask questions, getting us to come to the front and write or draw something, or explain something to the class or doing group stuff. At uni, the same things during tutorials. For engagement in lectures, if the lecturers go through the coursebook with you and draw it out (Sina, ANZE).*

Working in small groups was also beneficial for engagement and maintaining interest:

> *For uni and school, group assignments or activities [help]… because it forces you to get involved, you can't be the one sitting there not understanding things… that was a huge thing, especially in uni, group assignments were a big thing (Jake, ANZE)*

Enjoyment

Enjoyment is an aspect of psychological or emotional engagement (Fredericks et al., 2004). Emotional aspects of learning are often overlooked for more obvious signs of behavioural and cognitive engagement, such as participation and grades (Kahu, 2013). However, emotional reactions to a task play a key role as they suggest the student's intrinsic response and can be a crucial motivator for engagement (Kahu, 2013), also linked to achievement and success. Enjoyment is often considered as interest, and some researchers use the terms interchangeably (for example, Eccles et al., 1983, cited in Fredericks et al., 2004; Eccles & Wigfield, 1995, cited in Osborne, Simon & Collins et al., 2003). A recent TIMSS survey (2010/11) found that Year 9 students who were the most positive about learning science (i.e., agreed with statements such as 'I enjoy learning science' and 'I learn many

interesting things in science') had higher achievement than those who were more negative (Caygill, Kirkham & Marshall, 2013).

To define and measure enjoyment and interest the Organisation for Economic Co-operation and Development (OECD) PISA 2006 survey used words such as 'like', 'have fun', 'interest', 'happy' and 'enjoy', to capture the emotional reaction to a task or activity. The results from this survey indicate that 71% of Aotearoa New Zealand's students surveyed enjoy acquiring scientific knowledge, and 65% agreed that they had an interest in learning about science. This result may be related to the types of teaching and learning used, with 71% reporting experiencing interactive teaching approaches in their classroom, and the other types of activities they are engaged in, such as field trips and competitions (Coll et al., 2010). Hope (2009) suggests that specific active pedagogical approaches such as fieldwork can enhance links between emotional responses such as enjoyment and deep learning, ultimately developing essential skills such as critical thinking. These findings emphasise the importance of active learning for enjoyment, particularly regarding the teaching and learning methods used in science education.

The 2010/2011 TIMSS data also indicated that the Year 9 Aotearoa New Zealand students surveyed had a lower value and enjoyment of science in comparison to other countries (Caygill et al., 2013), while the 2014/2015 survey indicated only 36% of Year 9 students agreed that they enjoyed learning science 'a lot' (Caygill, Hanlar & Singh, 2016). These results have the potential to impact on the number of students continuing to study science in senior secondary school and tertiary. Thus, it is crucial to address enjoyment and consider the value of determining from specific ethnic groups, such as Pasifika, who have continued success with science what they enjoy about science and what interests them. What is enjoyment would be self-identified by the students themselves and be determined by the use of terms such as those used by the OECD PISA study ('like', 'have fun', 'interest', 'happy' and 'enjoy'). Identifying the positives that have influenced their engagement, and subsequent success and achievement, could assist teachers of science to adopt pedagogical approaches that will improve the learning experience and achievement of all their students, including Pasifika.

Tongan science learners' definitions of enjoyment.

Although the role of enjoyment in attitude and engagement is not well researched (Kahu, 2013), there are definite indicators that enjoyment (i.e., interest) plays a vital role in learning as engagement is strongly linked to achievement and success (Leach & Zepke, 2011). For these participants, enjoyment often aligned with a positive emotional response to learning new content or demonstrating understanding:

> *Feeling good about learning something new, or understanding something you didn't understand before, or finding out new ideas or being able to talk to about it [with] a family member or one of your mates… if you want to talk about, it's enjoyment. You wouldn't want to be sharing anything you don't like. If you like what you are doing, that would be enjoying it and passing as well, [that] makes you feel good (Naua, KOTE).*

Interestingly, most participants spoke about enjoyment relative to understanding and discovery, rather than the idea that something must be fun:

> *[At school] I knew my stuff, I enjoyed it, I didn't feel like I had to play catch up. When you're asked questions, you can answer them, that's enjoyment for me… true enjoyment comes from knowing my stuff and being able to participate… [at university] it's the same, if you go to a lecture and you understand what you are doing, it's enjoyable because you are learning instead of sitting there being totally lost (Grace, KOTE).*

There was some discussion of the relationship between understanding and 'fun', however: "*When I have fun in science is when I understand what I am learning… when I understand what I am learning it makes it more enjoyable because I don't feel dumb" (Lashandra, ANZE)*. Importantly, several KOTE participants spoke about how enjoyment came from being able to share their understanding with their family or broader community:

> *Knowing that I can help someone else out. I went to Power Up, for Pacific high school students, it felt good being able to help another Tongan or Pacific student with science, so that makes me happy, knowing I can help someone out (Setaita, KOTE).*

For the ANZE participants, understanding also related to wider concepts such as knowing how science could be a potential career pathway, and having positive feelings about what they are studying:

> *Other than loving what you are learning in lecture and labs… the biggest thing is*

> *making sure you understand why you are doing this and where it's going to get you after uni, and whether you are going to enjoy that kind of thing. It's also going to sleep knowing you are loving what you are doing, waking up [thinking] now I want to go and do what I am doing, that is enjoyment for me (Jake, ANZE).*

Seeing the relevance of what they were learning also increased enjoyment, the same participant continued,

> *With medicine… it's enjoyable now, because I am out there doing what I wanted to do in the first place… that's a huge thing. I am applying the science that we learnt in lecture that I have studied for so long, seeing it in in real life for the first time is cool… that has been the biggest thing (Jake, ANZE).*

Very few participants associated enjoyment purely with getting good grades:

> *Understanding, getting to a solution that I didn't know I could, and probably getting a good grade. In the first half of this semester we had a test, I got a B+, I was pretty happy. That gave me an extra boost to know that I could do it (Fifita, ANZE).*

A small number of students felt that deportment, demeanour and body language indicated enjoyment, but more often it was whether the students were doing tasks given to them by the teaching staff and asking questions. Off-topic questions also suggested students are interested in what they are learning about:

> *Doing well won't tell you; they might've rote learnt it. But the students wanting to know more, asking a question that would get the lecturer thinking… In my neurology paper, students would ask questions that are not far out of the scope of what we learnt and that made the lecturer… I remember him saying, 'Oh, you guys are listening!' (Takai, ANZE).*

The participants also made linkages made between enjoyment and other aspects such as engagement and achievement:

> *Enjoyment in science? …To me, the main thing [is] to enjoy it in order to engage and if I want to learn about it… Being interested in what you are studying… say if you calculate something, and you get the answer… that achievement, I find that enjoyable, and calculating, because I am a geek… that part in itself is enjoyable (Setaita, KOTE).*

Achievement also helped participants enjoy their science studies: "*the feeling when you accomplish something, that helped me to enjoy, that's what helped me to start learning again, the adrenalin of getting a good mark, I wanted to keep that momentum" (Fifita, ANZE)*.

Considering enjoyment for teaching and learning.

Most participants enjoyed it when teaching staff used a variety of ways to deliver the content:

> *I think finding those creative ways to teach it, so teachers using drawing to help teach something that would [otherwise] be a page of writing …Using colours and flow charts, that was helpful. that helps me to understand it more and remember it, so that helps me to enjoy science (Lashandra, ANZE).*

> *Sometimes when they talk its boring, I would like them to change it up, especially when some of my lecturers are monotone. I easily lose track of what they are saying, (Kalala, ANZE)*.

Working through the lecture content with the lecturers was also more enjoyable than passively listening:

> *Going through the lecture information with the lecturer at the same time, we are engaging with the information because we're obviously following what they are doing, and filling in blanks, colouring-in, at the same time he is explaining, so you understand the information (Avila, ANZE).*

Practical learning or application, such as field trips or labs, also helped enjoyment:

> *With biology… I enjoy hands-on work and having an invested teacher. He cared that you would pass, that meant a lot… group work, being able to discuss your ideas, projects, I enjoyed those, doing research assignments* (Lupe, ANZE).

Different learning environments helped enjoyment:

> *I had this teacher, he loved bio, and it made me love bio. He made it so interesting… We would go outside and look at what we were learning about… not sitting in the classroom, the way he explained things was funny, so it made us listen…* (Soana, KOTE).

Another participant highlighted the importance of positive feedback for enjoyment:

> *I was always interested in science. I think doing well; if I got good marks I wanted to keep going, when someone tells you are good at something, when you know you are good at something, it makes it more fun* (Laulea, ANZE).

Another way to increase enjoyment was making the content relevant to the student cohort:

> *I enjoyed doing the research assignments. I did immunisations, which is a topic that everyone talks about, but you don't understand why. I enjoyed it because I*

felt like it was something I could contribute more in a conversation (Lupe, ANZE).

The participants found more factors that helped their enjoyment at university than at secondary school, including having peers studying the same programme: "*I like that you are studying with people that are pretty much all doing the same papers as you*" *(Avila, ANZE)*. The content they were learning about also helped:

> *At uni I am starting to understand things more, starting to learn more, it's interesting how things work. We did a research assignment, I researched about HIV, and this drug that inhibited its function, it was interesting how people came up with that stuff and how it works* (Fifita, ANZE).

The participants identified several aspects that had hindered their enjoyment at university, including the workload*:*

> *The workload, there is so much, they need to slow it down or make it less. There is a lot of rote learning too, and that makes me not enjoy it sometimes… There is so much rote learning to do in order to pass… (Laulotu, ANZE)*.

Success

Success is another term that is widely used in educational literature but often not clearly defined, perhaps because, like achievement, it is relative to the context and strongly tied to other key aspects of learning, such as engagement. It is a very complex concept, and the scope of its interpretation is broad and can include "increasing or widening participation, achieving high levels of course completions, and attaining a passport to employment with a positive attitude to lifelong learning" (Yorke, 2006, cited in Zepke, Leach & Butler, 2011, p. 227). Success in education is important for individuals, their families, communities, and the society they live in as it can determine employment opportunities, income, and contributions to their community. Typically, the more educated people are, the more they earn, the better educated their children are, and the more they can contribute to the development of their community and the economic growth of their country (Statistics New Zealand & Ministry of Pacific Island Affairs, 2010).

Regardless of educational level, several different factors influence educational outcomes, such as attendance, engagement, and participation in relevant learning and achievement (Education Review Office, 2010). These factors can also, in turn, be used to

measure success, according to 'hard outcomes' (retention and completion) or 'soft outcomes' (engagement, achievement of personal goals) (Zepke et al., 2011) highlighting the complexity of separating out key ideas such as success, engagement and achievement which all interact and overlap with each other in various ways. Most definitions and research on success focuses on institutional factors related to success, such as teaching and learning approach and institutional processes, for example, in Aotearoa New Zealand's secondary schools, student success is strongly related to numeracy and literacy skills and the ability to apply them (Education Review Office, 2010); this, in turn, determines achievement (and access) to tertiary education (Statistics New Zealand & Ministry of Pacific Island Affairs, 2010). There is often limited focus on non-institutional factors, including family, cultural, and personal influences, which heavily influence success, especially for specific ethnic groups such as Pasifika (Zepke et al., 2011). For example, although success can be related to confidence and self-belief, Pasifika students are often not confident in their ability and "attribute success or failure more to luck, peers or family than their own ability and effort" (Statistics New Zealand & Ministry of Pacific Island Affairs, 2010, p.11). Therefore, for the purposes of this study, success is defined based on Airini et al. (2009), as the,

> movement towards and achievement of pass grades or higher, a sense of accomplishment and fulfilling personally important goals, and participation in ways that provide opportunities for a student to explore and sustain their holistic growth. The concept of 'success' is a broad one that links with individual and community notions of potential, effort, and achievement overtime (p. 5).

Tongan science learners' definitions of success.

The importance of family, cultural, and personal influences on success for Pasifika students are often not reflected in most definitions of success, which emphasise institutional factors (Zepke et al., 2011). The definitions provided by the participants in this research indicate the role played by these non-institutional factors, reflecting Airini et al.'s (2009) definition, which incorporates achieving grades and personal goals as well as collective concepts of achievement. Importantly, the participants also acknowledged traditional Tongan educational values such as *poto*, or, "[skills], utilised for the greater good of the society" (Māhina, 2008, p. 83).

Most KOTE definitions of success had an academic focus: *"success, would be, academic-wise, finishing what you are studying, having the grades that you want, that you strive for, that would be success"* (*Naua, KOTE)*. Often, they defined success by results: *"Being able to pass all papers with either an A- to an A or maybe a B+; a B+ is good for me, but A or higher would be success*" *(Inoke, KOTE).* Grades were also an important measure for parents to understand success:

> *Success in different contexts can be measured differently… in science; the first step is passing, that to most parents is success, like you made it! Second would be if you are going from high school to tertiary, getting into a degree to do science, getting into university, doing a science [degree] (Grace, KOTE).*

Other KOTE participants indicated grades and employability demonstrated success:

> *For the degree it would be passing with great grades, not getting a C, and being able to continue with it after your degree… so if you find a job, or find the interest that makes you want to keep [pursuing] research or postgraduate studies, that's what I think is success (Mele, KOTE).*

Interestingly, some KOTE definitions of success emphasised understanding over grades:

> *Obviously, success would be getting good grades, but to me it's more, it's… achieving, discovering what [something] is and attaining the knowledge that you have always wanted to know or been curious about. Getting all the information about what you wanted to know, attaining that is being successful (Katinia, KOTE).*

Success was also the ability to interact with others and share knowledge:

> *I understand there are different parts [of] science you can be in successfully, but, I always think being a good scientist would be helping others, or providing easier ways for kids, and encouraging other young people who want to be successful in science, helping them grow with their understanding and what they love about science, that would be a successful scientist or [success] in science* (Vaea, KOTE).

Broader definitions included discussions of how Tongans recognise success and what is successful:

> *If you apply what you learnt into the community and you have something to show for it. I think that's what most Tongans do, we like to see people succeed. [My family] are waiting for me to graduate and go back to Tonga and do something amazing. Actions speak louder than words, so you must show that the degree is useful… that's what success is (Grace, KOTE).*

For the ANZE participants, success was related to grades, but also understanding and applying content knowledge:

> *Success in science for me means you are not just passing, you are doing well in your studies and you understand it. You are not rote learning it, you are able to apply it in everyday situations and you are critically thinking about your different sciences and asking questions of why stuff happens, and things like that (Sina, ANZE).*

Often this application would assist the wider community: "*In medicine… success is somebody who makes a difference, that's cliché, you don't have to have a lot of money, but you go out into the community, and you try and improve things*" *(Soana, KOTE)*. Another participant explained this further:

> *Using your knowledge, or your interest in science… [to] help improve something in society, taking advantage not of your gift, but your love or passion for science, using that in a way to make things better. That's what I think success is. It's not acing grades or anything like that, people could do quite average in science at uni but still make a big change in society and… that's more important than anything else (Jake, ANZE)*.

Success also related to how their family could benefit: "*success in science is reaching the highest level you can reach, so if you can reach postgrad then that's success, and hopefully getting a great job after that will support yourself and your family in the future" (Manu, ANZE)*. A few participants in the ANZE group implied an element of individual responsibility is essential to success: "*If you are determined to be successful, you will be, it doesn't matter how the teacher teaches you, you should be able to find your own way*" *(Laulea, ANZE).*

Considering success for teaching and learning.

Factors that contributed to success at secondary school were often the teachers:

> *My [school] science teacher was motivating and pushing me, when he would present his stuff in class, he would be proactive about it… he was really motivating, the way he talked. Sometimes he would go outside the scope of what we learnt in class, he would say 'This is the reason that this happened' and that was interesting to me (Takai, ANZE)*.

Being exposed to different teaching approaches and their desire to do well and follow particular career goals also helped:

> *Being interactive in class and being part of it... having your own interest in it rather than seeing it as a class where you earn credits. For me, it was my goal of medicine, that [was] the bigger picture in mind (Lupe, ANZE)*.

Other factors included family: "*A lot of things [helped], everything around me… my family support, both my parents are always encouraging me"* (Soana, KOTE).

Some students indicated that achieving good grades early in their secondary school made them overly confident, resulting in lower grades later:

> *I didn't do that well, it was a bit of a social school, so I didn't worry much about how to study. I worried about passing instead of getting the grades. In [Year 11] I did well, but then I started to drop off in [Year 12], I was over school. [Year 11] was my peak [laugh], I did well in the tests but then I started to drop off because I [thought] 'Oh, I can do it last minute, I might as well do it last minute', it was a bad study habit* (*Fifita, ANZE).*

The different teaching styles at university helped some participants to succeed, as well as having a larger cohort of Tongan (or Pasifika students): "*I liked the lecturers' teaching styles, and the environments we learned in were cool. I also liked that I knew heaps of Islanders, that was cool, learning with different Islanders*" *(Avila, ANZE)*. Another factor for success was to be goal-oriented:

> *If you set a goal, it's easier to work towards something than to work through something blindly. At high school when I had set my mind on going to uni and getting into medicine, that set me up for something I wanted to do. I made sure I had to do this and that and get these kinds of grades. At uni, you can set different goals, especially with medicine there are so many different things you can aim for (Jake, ANZE)*.

Fata ho poto Model

The participants are diverse regarding their secondary school education background (in Tonga or Aotearoa New Zealand), socio-economic status (as suggested by their secondary school decile rankings), and family history of study. This diversity provides a valuable insight into the heterogeneity of the Tongan science learner population in higher education in

Aotearoa New Zealand, regarding their understanding of engagement, enjoyment, and success as outlined above.

For engagement, the participants' insights generally aligned with Kahu's (2013) engagement framework. They all considered relationships with staff an important antecedent and how teachers demonstrated their interest in the students, or the subject influenced how students then engaged. Most participants suggested that asking questions indicated engagement, but a few indicated that their engagement is not distinguished by asking questions or interacting with teachers. This difference of opinion is important because it contests the belief that Pasifika students are shy and do not ask questions; these comments are a means to highlight the heterogeneity of Pasifika students and counter stereotypes. Interestingly, there were also differences between the two groups: KOTE participants described engagement in science as demonstrating a passion for learning and a desire to share their knowledge; ANZE participants described engagement as active involvement in learning. For both groups, the goal of attending higher education (distal consequences) drove engagement in secondary school science; at university, their interest and enjoyment of what they were learning about (proximal and distal consequences) drove their engagement.

The descriptions of enjoyment (i.e., like, have fun, interest, happy, and enjoy[31]) overlapped with their stories of engagement. As enjoyment is a form of emotional engagement (Fredericks et al., 2004), this makes a lot of sense. Overall, the participants described enjoyment as feeling good about learning or discovering something new, or demonstrating understanding, rather than as something fun. Enjoyment was not generally associated with academic results. Interestingly, for the ANZE participants, enjoyment also came from understanding how their science studies contributed to a career pathway as it then had increased relevance to them, associating it with a career helped them to understand the purpose of the subject and why they should be interested. Using a diverse range of techniques helped their enjoyment, especially opportunities to work collectively, particularly in a structured way with the teaching staff. They also enjoyed practical applications, and when the content was made relevant to them through the use of analogies, stories, and association with familiar objects or cultural references, teachers heavily

[31] These terms come from the OECD PISA 2006 survey (see Coll et al., 2010).

influenced their enjoyment in the manner in which they taught. At secondary school, enjoyment was associated with grades, but this was replaced at university by understanding. University science learning was more enjoyable because of the understanding they had of content but also because they had more Pasifika students to learn with.

Previous researchers such as Zepke et al. (2011) have critiqued the focus of mainstream definitions of success on institutional rather than non-institutional factors as problematic for ethnic groups such as Pasifika. The successful Tongan science learners in this research considered grades and employability as evidence of success but also their understanding and sharing of knowledge with others to help them. Like their discussions around engagement and enjoyment, understanding was linked to success. Teachers and family support also played an important role in their success, as did the increased number of Pasifika learners in their science classes at university compared to their secondary school experience. *Fata ho poto* (see Figure 6) visualises these three terms from the perspective of a successful Tongan science learner and demonstrates how these terms interconnect and overlap for them.

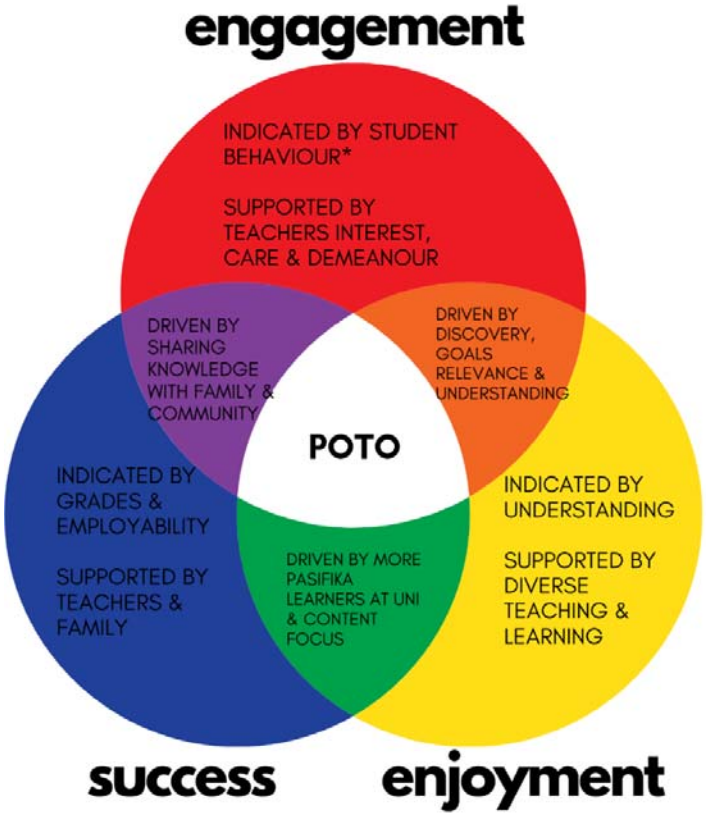


Figure 6: Fata ho poto: Visualising Tongan science learners' considerations and experiences of engagement, enjoyment, and success.

Fata means 'to carry', *ho* means 'your' and *poto* is a core concept in Tongan education (Thaman, 1988), defined as ''to be clever, skilful; to understand what to do and be able to do it' (Churchward, 1959, p. 125). It has also been described as 'to be wise', wisdom, knowledgeable, and as skill to be used to benefit society (Māhina, 2008). *Fata ho poto* acknowledges that for these Tongan science learners to achieve *poto* is a sacrifice. Most are carrying the burden of sacrifices made by family, such as migrating to Aotearoa New Zealand. Many participants were also balancing family expectations to study and their contributions to their *famili* (immediate family). Essentially, *Fata ho poto* intends to emphasise the collective (i.e., family, friends, teachers, peers, etc.) rather than the individual that influences engagement, enjoyment, and success for successful Tongan science learners. This model centralises *poto* because it underpinned the participants' explanations of all three terms. Importantly, the participants associated *poto* with achieving a depth of understanding in their studies that can help their families or communities either through employment, or the dissemination of valuable knowledge gained from their science studies.

Concluding comments

The participants had very clear ideas of what engagement, enjoyment, and success were for them and how they had experienced them in the formal learning spaces of their science education. Much of what they describe aligns with other understandings of engagement, enjoyment, and success. However, there are unique elements: the importance of understanding so that they can share knowledge with family and community; the influence their teachers have over their engagement, enjoyment, and success; the view that enjoyment is driven by understanding rather than fun or entertainment; the opportunities for working collectively; the valuing of content relevant to their lived experiences; and the effect of being

the ‘only brown person’ in their science education experience until university. These ideas are also woven into the following chapters, beginning with their thoughts on ISK.

Chapter Five – Their voices: Science and Indigenous (science) knowledge

This chapter explores the participants' narratives regarding their perceptions of Tongan science knowledge (TSK), and how their formal education included TSK in Tonga and Aotearoa New Zealand. It also describes their thoughts on how westernisation has affected their ability to recognise and value TSK, as well as which Tongan cultural values and knowledge might be useful to include in and assist the delivery of the formal curriculum. A key argument of this chapter is that the presence of TSK in the formal curriculum in Aotearoa New Zealand would address issues of engagement, enjoyment, and success for Tongan science learners. Overall, the inclusion of TSK acknowledges its existence and value and creates the opportunity for positive impacts on wider factors such as learner identity, especially for Tongans raised and educated in Aotearoa New Zealand. I also provide examples in this chapter of how I amended my curriculum to enlarge my students' worlds and their Pacific Island futures.

Indigenous science knowledge

Indigenous knowledge (IK), as defined by Castellano (2000), includes knowledge which is shared by elders and inherited across generations, empirical knowledge collected from observation and awareness of the local environment, and revealed knowledge which comes from dreams, visions, and intuition. Indigenous knowledges are personalised rather than universal, orally transmitted, and holistic. These knowledges are also relational, experientially based, current and historical, have elements of subjectivity, and are trusted because of the integrity of who shares them.

The difficulty of naming and defining knowledge which belongs to Indigenous cultures reflects the way that it is often perceived. Whereas WMS knowledge is easily recognisable and has a high social value, labels such as local knowledge, traditional, or IK are attempts to capture what Indigenous cultures know about the natural world. As a term, 'science' usually implies WMSK, something that is important, without needing any extra adjectives or

descriptors, while ISK is often presented as *"everything that is 'not science'"* (Nakata, 2007, p. 9).

Aikenhead and Michell (2011) have argued that using a term such as 'Eurocentric science' indicates that other sciences exist. Ogawa (1995) considered all cultures to have their science, termed their 'indigenous science'. He defined this as knowledge:

> held by a specific cultural group, not by a specific individual. Indigenous science may be of a nature such that even individuals living in that culture may neither recognize its existence nor be aware of being governed by it tacitly. Also, indigenous science might be tacitly transferred from generation to generation through daily social and cultural events (p. 586).

Such a pluralist perspective (McKinley, 2007), creates the opportunity for an equitable approach to different forms of knowledge as it acknowledges that other sciences exist (Ogawa, 1995). It also acknowledges the 'cultural border crossing' (Aikenhead, 1996) that occurs in science for non-western students who must navigate a heavily western focused and informed curriculum. Therefore, in this research, I have intentionally chosen to use the terms 'Indigenous science knowledge' (ISK) and 'Tongan science knowledge' (TSK) alongside western modern science knowledge (WMSK).

I use ISK because it is well recognised in the literature but, more importantly, because it achieves the pluralist and equitable approaches suggested by critical realism and the MSF. As noted in Chapter Two, WMS can be considered a subculture of western culture because it shares a well-defined system of norms, values, meanings, and symbols. The prestige and power associated with western culture and WMS often allows it to assume priority in non-western cultures. As a result, WMS can displace the local IK, usually through assimilation or acculturation, causing some to label WMS as a "hegemonic icon of cultural imperialism" (Cobern & Aikenhead, 1997, p. 3). This situation incentivises the adoption of Ogawa's Multiscience education framework as it awards all sciences equal ranking.

I have been questioned about my use of TSK, particularly whether it is science or is it knowledge or is it a cultural practice and so on. I use WMSK because it acknowledges that this science has a timeframe and is heavily westernised, despite much of the knowledge

having non-western roots[32]. I use TSK because it elevates this body of knowledge to that of 'science,' i.e., WMSK, and makes it recognisable, particularly to students who have only experienced science as something western. Other terms, such as Cajete's (2006) "native science," have been used for the same purpose, to acknowledge ISK and consider it equitably.

If IK is not included in the formal science curriculum (Howlett et al., 2008), this exclusion can maintain the feeling of being 'othered' or deficient in an educational institution's culture because of the inherent social and cultural bias that favours the dominant social groups (Bishop, Ladwig & Berryman, 2014; Kahu, 2013). Celebrating multiple perspectives by including IK into curriculum challenges the hegemony of WMS (Hammond & Brandt, 2004) and has benefits for all students, their institution, and wider society (Thaman, 2003). This position is something that became a major focus for me as I grappled with how I could pluralise the content or approach in my courses.

What is science?

It is necessary to begin this chapter with an understanding of how the education system in Aotearoa New Zealand defines science. This definition creates a boundary of what the term 'science' categorises as knowledge, information, or thinking. According to the NZC (2007), science is:

> a way of investigating, understanding, and explaining our natural, physical world and the wider universe. It involves generating and testing ideas, gathering evidence – including by making observations, carrying out investigations and modelling, and communicating and debating with others – in order to develop scientific knowledge, understanding, and explanations. Scientific progress comes from logical, systematic work and creative insight, built on a foundation of respect for evidence. Different cultures and periods of history have contributed to the development of science (Ministry of Education, 2007, p. 28).

When compared with Ogawa's (1995) definition outlined above, the NZC (2007) definition emphasises the process of acquiring scientific knowledge, particularly the systematic nature of proving it, rather than science being a cultural way of knowing and explaining that does not have a particular method or requirement for evidence. IK is often transmitted orally by

[32] WMS has been heavily influenced by the knowledge and wisdom of other cultural groups throughout its history of development. WMSK is not derived only from western culture and scientific practice. It also consists of adopted learnings, findings, and knowledge from other cultural and ethnic groups.

story, song, or dance, which can be hard for those with a western bias for paper-based transmission to appreciate (Snively & Corsiglia, 2001). More often than not, considerations of WMS overlook the reality that much of WMS has been 'borrowed' (in some instances entirely appropriated) from other cultures. However, this all contributes to the universalistic perspective equating only WMS with 'science', allowing it to operate as a gatekeeper for what can be considered science in an education system. This universalistic thinking usually displaces other local IK so that true multicultural[33] science cannot be represented (Snively & Corsiglia, 2001) and encourages the existence of a hidden curriculum, such as the supposed superiority of WMS knowledge (Kidman, Chiung-Fen & Abrams, 2013).

Secondary school science in Aotearoa New Zealand.

Science is one of the eight learning areas[34] outlined by the NZC (2007), which also covers 'principles' for decision-making by the school, 'values', and 'key competencies'. Science has five 'strands'; four underpinned by the core strand, 'Nature of Science'. This strand focuses on what science is and how scientists work and is required learning until Year 10 (usually 14 to 15 years old). Students develop four skill areas: 'understanding', 'investigating', 'communicating', 'participating and contributing to science'.

During the first four years of secondary school, science education focuses on the understanding of current social issues and aims to teach critical thinking, discussion, and exploration of these issues. Schools can design their curriculum to reflect and meet the needs of the communities they serve, and there is an opportunity here for community expertise to develop programmes that reflect local issues. The senior secondary years (Years 11-13), place an increasing emphasis on preparation for university and careers in science, but socio-scientific issues are still explored as is scientific thinking and knowledge (Bull et al., 2010). Secondary science education has expanded its focus from 'pre-professional' preparation of

[33] Multicultural science is a response to multiculturalism's recognition of diversity. It can be defined as "a construct, a process, and an educational reform movement with the goal of providing equitable opportunities for culturally diverse student populations to learn quality science in schools, colleges, and universities" (Atwater & Riley, 1993, p. 664). However, Ogawa argues that without recognising the multiplicity of sciences, multicultural science is only about a culturally responsive science education for addressing the needs of a multicultural classroom. He urges that because 'science education' is WMS, if that is not acknowledged, then what and how we teach science cannot change.

[34] Each 'learning area' of the curriculum has several levels. One 'level' typically covers about two years of learning.

students for tertiary study to incorporating 'citizen-focused objectives' such as scientific literacy and understanding of the world and how it works (Gluckman, 2011).

Where is ISK?

Although science supports problem-solving, decision making, and employment, we must recognise that other forms of knowledge, including ISK, helped people problem solve and make decisions long before WMS evolved. Perhaps if this knowledge was valued more and more obvious in the curriculum, Indigenous science learners would be able to be more successful.

'Nature of Science' has four achievement aims: understanding science, investigating, communicating, participating and contributing in science. Based on their curriculum descriptor, each, except perhaps the current definition of 'communicating in science', would allow ways to introduce, include or utilise ISK. For example, one aim within 'understanding about science' is to know that science is a knowledge system. If students are to know it is 'a' knowledge system and not 'the' only knowledge system, there must be other knowledge systems presented; a similar argument to the one for using the phrase WMSK instead of labelling it science. Furthermore, to develop students' understanding of how scientific knowledge and processes come about, it would be useful to see where WMSK originates from and how it has developed over time by incorporating other forms of knowledge. 'Investigating in science' creates the opportunity to see that other forms of knowledge follow similar approaches such as pattern-seeking, exploring, and making things. When 'participating and contributing' in science, students need to use their scientific perspective and thinking to make appropriate decisions. If we also desire active citizenship in society (Gluckman, 2011), it would be wise to encourage science learners to reflect on the decisions needed in their communities, and how their ISK could have value in this decision making. However, all of these suggestions are only possible if other forms of knowledge are considered and identified as science too.

Renaming the current definition of science in the NZC (2007) as WMSK would indicate that other scientific forms exist, that science is not one thing, and affirm that other knowledge forms are equal or comparable. As a result, examples of these knowledges would be necessary for curriculum delivery; they would need to become part of the 'empirical'

realm of the student experience. It is harder to gauge where ISK exists in the delivery of science at the tertiary or university-level. One factor that complicates this is that faculties, schools, departments, programmes, or individual course coordinators determine course curricula. Unless these parts of the institution are working towards achieving a particular goal or objective aiming to include or recognise ISK, it would be unlikely to happen as there is no central organisation determining curriculum content like there is for the compulsory education sector.

Embedding IK into the teaching and learning of science across all levels of the education system would help Indigenous science learners to build their cultural capital in the classroom and as a science learner. Phrases in the NZC (2007) that suggest science 'in everyday situations' lend themselves to encouraging students to use their own everyday situations, creating an opportunity to showcase diversity, especially around approaches and knowledge that are *"*a way of investigating, understanding, and explaining our natural, physical world and the wider universe*".* More opportunities exist when exploring the specific Levels associated with the Nature of Science stream. At Levels 3 and 4, when students are aged 7-15 years old, they need to understand and "appreciate that science is a way of explaining the world and that science knowledge changes over time". Furthermore, when investigating in science, they should *"*build on prior experiences, working together to share and examine their own and others' knowledge*".* At Levels 7 and 8 (13 to 18 years old), students are expected to understand that science must link "ideas to current and historical scientific knowledge" (Ministry of Education, 2007b, p. 42). Broadening this to include other forms of knowledge and experience would increase engagement with identity, enhance social cohesion and understanding of others. Acknowledging that ISK/TSK is science means that students would be able to connect historically to this knowledge; if this is not recognised, overlooking the socio-historical context of the students, and also the region where all science learners in Aotearoa New Zealand are growing up and learning, misses an extremely rich opportunity for them to understand their geographical and historical context and how that translates to their current lived reality.

Secondary school science as a sub-culture.

Before continuing further, it is important to consider the impact of globalisation on education, particularly on the delivery of local knowledge. Globalisation is a complex process

that blurs international boundaries economically, politically, culturally, and socially by increasing global connections. It is not homogeneous and has manifested itself in multiple ways over the many decades. In its current neoliberal form, globalisation is spreading a dominant set of western industrialised knowledge, values, and practices replacing local IK and wisdom (Thaman, 2003).

As a result, the science taught in many schools internationally closely aligns with WMS. Some argue that this enables the cultural transmission of the subculture of science and the mainstream (or dominant) culture (see Cobern & Aikenhead, 1997). As discussed previously, critical realism holds the notion of a stratified ontology in which three realms exist: the real, the actual, and the empirical. The teaching and experience of school science is influenced by: what is considered possible (real), what becomes possible (actual), and what has been noticed (empirical). Whereas the positivist influence of WMS determines what is noticed and, thus, taught. Therefore, if the mainstream culture matches or aligns with students' cultures, this can enculturate or support students to learn about science; yet, for many students, these cultures can be in contrast to, or contradict their everyday culture (Ogawa, 1995). This contradiction can disrupt their view of the world so much so that they replace, or reconstruct, their IK with WMSK, or at least shift the hierarchy so that WMSK ranks higher (Cobern & Aikenhead, 1997).

This process of assimilation often disempowers Indigenous and other minority students, usually impacting on their academic achievement and their identity as science learners. Yet, there are examples where students have resisted assimilation by working the system to their advantage, so that they learn the content enough to pass the course but not so that they lose their identity (Cobern & Aikenhead, 1997). One example is 'anthropological learning' (Aikenhead, 1996), where students do not change their culture to accommodate the subculture of science; instead, they make meaning out of the subculture of WMS without assimilating or acculturating so that they have to change their culture. They can negotiate their two worlds, that of their every day and that of their science course.

Aikenhead (1996) describes the process of science learners moving from the subcultures of their families and peers into the subculture of school science and science as 'cultural border crossing', an activity that is critical to learning science. If, during the process

of learning, the subcultures represented are similar or the values align with their culture, the student can become enculturated into scientific thinking. This enculturation is a positive outcome as they are supported to learn about something that aligns with the way of thinking they already know. For students whose cultural identity contradicts or is disrupted by the subcultures of science and school science, it can negatively impact on their learning. Often, they are expected to assimilate to succeed, replacing their way of thinking with that of the culture of WMSK. Unfortunately, this can often result in the rejection of key aspects of their cultural identity and way of being.

The following narratives will describe the experiences of Tongan science learners in secondary school and university science classrooms in Aotearoa New Zealand, regarding ISK and WMSK. Some of these narratives demonstrate the effect of learning WMS and provide examples of acculturation and/or assimilation occurring in the classroom. By contrast, other narratives showcase examples of anthropological learning, as well as culturally responsive teaching, as examples of resistance to WMS.

Tongan science learners' definitions of science.

To understand what participants thought when they heard the phrase 'Tongan science', they were first asked to define what 'science' meant for them. The definitions for both groups are described together here because they are very similar, often including phrases such as 'understanding the world' or 'how everything works', For example,

> *Science is the way of understanding the world around you …if you want to understand things around you, people around you, that's what it is, if you want an understanding of the world you are in, that's what science is (Katinia, KOTE).*

Interestingly, one participant spoke about how their perspective on science had changed since they had begun studying it at university:

> *I didn't think I would continue into science because I didn't like it at school. I guess it's a foundation for everything, now I see things very differently, now I think more about: Why does that happen? How does that happen? …I am asking those questions more because of science …it's a foundation of a way of life (Sina, ANZE).*

These definitions echo the goals of the NZC (2007) as the participants were able to articulate the elements of explaining, questioning, and, particularly, understanding how

things happen. However, many participants were unable to define science without referring to the 'hard' sciences (biology, chemistry or physics): *"…when I think of science, I think of biology… to me, science means biology but specifically the human system, the body, how the body works" (Mata, KOTE).* This perspective is understandable as it reflects the prioritising of WMS in the education systems in both Tonga and Aotearoa New Zealand, and the acculturation of students into thinking about science from a western framework that compartmentalises by subject and practice. It also demonstrates the need to shift the ontological positioning of those who determine what science encompasses, as the 'empirical' realm of someone with a Multiscience viewpoint is likely to be different from that of someone who holds a positivist position and favours a 'positivist orthodoxy'.

This limited acceptance of other conceptualisations of science knowledge can create issues, particularly if minority cultural groups have beliefs that contradict WMS. For example, a few participants mentioned the influence of religion in their interpretation of science:

> *Science, from my Tongan point of view, it comes under God, the whole idea of religion. My definition of science is trying to understand what God wants us to understand… and knowing about living things and what we do …that's what defines sciences (Vaea, KOTE).*

Considering that different cultural groups have their descriptions and explanations of nature, critical realists would argue it is important to recognise what is valuable for them and why, and what they consider to be 'real' or what they have noticed in the 'empirical realm'. For example, recognising the importance of God for many Tongans, or having a strong spiritual or religious faith, is a position that is often dismissed by science educators as believing in something that is not real, visible, or proven. Overlooking these differences does not help students to border cross into the subculture of WMS; acknowledging these differences, valuing them and considering how and why these perspectives exist, could help.

What is Tongan science?

How each participant defined 'science' was used to drive discussions around 'Tongan science'. The first definition was used as a reference point because the immediate response to the topic of Tongan science, as well as interpretations and thinking around what it meant, were highly variable. Interestingly, like their definitions of science, many participants

referenced western categories of 'hard' science in their initial attempts to define Tongan scientific knowledge, demonstrating the acculturation that is occurring, for example:

SF: What do you know about Tongan science?

Naua: Tongan science? Are we talking about biology?

KOTE and ANZE participants gave similar answers to this question, suggesting WMS has enough influence in both countries for the participants to use it as their benchmark of science.

KOTE participants.

In general, the participants in the Kingdom of Tonga Educated (KOTE) group came to a definition of Tongan science reasonably quickly, primarily through their discussions of examples. According to Ogawa (1995), each cultural group has an Indigenous science which may or may not be apparent to the individuals living in that culture. It is more likely that they will become aware of the influence and existence of their Indigenous science if they have experiences of a foreign culture. This awareness also seems to be the case for the KOTE participants, most of whom spoke about Tongan medicine, although some also mentioned navigation, cultivation, and cooking. Whether this is because they have experienced a foreign culture (i.e., Aotearoa New Zealand) and been able to reflect on their upbringing or because they had more exposure to this form of knowledge in Tonga is debateable, and probably varies by individual. Nevertheless, even though they were able to give examples more easily than the ANZE participants, in most interviews, there was some initial confusion around the topic of 'Tongan science'. This confusion affected how some participants first answered the question; for example, one participant thought 'Tongan science' was a reference to science education in Tonga.

It is possible that if a Tongan speaker had conducted the interviews, the participants might have had more success with understanding and responding to the question. Aside from this potentially limiting factor, it is also essential to consider how influential the western system of science education, which typically focuses entirely on WMS, is in both Tonga and Aotearoa New Zealand. For the most part, the concept of recognising or valuing TSK was a new one for most of them, *"…Growing up, science was always a western concept and in my*

Tongan culture upbringing, there was no concept of science. If I was to translate it into Tongan, there is no word for science" ('Ana, KOTE).

When participants spoke about TSK, there was often a distinct hierarchy regarding which scientific knowledge, Tongan or western, carried more weight. This was evident in the narratives that considered Tongan science as something that wasn't as valuable as WMS because it was perceived to be without substance, thought or proof, "*I feel that the Tongan traditional stuff, they are uneducated, they use the leaves because they know their grandparents told them to use the leaves, they don't know why they are using it" (Fatai, KOTE)*. This narrative reflects the participants' exposure to WMS and its underlying principles, for example, how to research and do science 'correctly'. The hierarchy of scientific knowledges often created some difficulty for the participants, particularly the idea of considering some Tongan cultural knowledge as scientific knowledge that has been in use for thousands of years:

> *SF: …what has helped Tongan people exist for thousands of years …navigation, planting… would you consider that science?*
>
> *Fatai: Yeah, I would consider that science. Is that science? Or, is it general knowledge being passed down?*

According to Ogawa (1989), Indigenous people may not recognise science in their culture; the transfer of such knowledge occurs informally and invisibly between the different generations without a specific name or phrase labelling it. As outlined above, his later research suggests that when confronted with a foreign culture, the existence of their Indigenous science usually becomes more noticeable (Ogawa, 1995). Yet, in this research, even though most of the KOTE participants had spent at least a few years in Aotearoa New Zealand, they had not yet started to recognise their Indigenous science as science.

From a cultural anthropology perspective, teaching is a form of cultural transmission while learning is a process of cultural acquisition. If the students and teacher share the same culture, then they have the same norms, values, beliefs, and students this process can be relatively straightforward; if they do not share the same culture, it becomes more complicated. To further complicate matters in science education, science is often considered a culture of its own, with particular meanings, symbols, and protocols, which is why concepts

such as cultural border crossing (Aikenhead, 1996) and collateral learning (Jegede, 1995) can apply to science learning. According to Aikenhead and Jegede (1999), cultural border crossing argues that most students have to traverse from the culture of their everyday life to the culture of the classroom where they learn science; the closer the culture of the student's everyday life is to the subculture of science, the easier this border crossing is. It is evident from the following narrative that this border crossing process has been a struggle for some participants, resulting in them replacing their Indigenous concepts with those of WMS.

The influence of WMS affects the KOTE participants' ability to see that Tongan cultural knowledge, including valid and successful 'scientific methods,' has been built over thousands of years of experimentation, even when they were able to give thorough explanations of how Tongan traditional knowledge is science. For example,

> *Grace: I don't think it's called Tongan science, I think it's called Tongan voodoo [laugh] …as Tongans, we don't have hard evidence on anything. …their science is more around trial and error?*
>
> *SF: Isn't that science?*
>
> *Grace: Yea, its science but they don't understand the concepts behind it.*
>
> *SF: Do you think that Tongans have a 'science', a traditional knowledge?*
>
> *Grace: Yeah, we do. Cooking our food, in the ground, the umu (underground oven)… that's a science. When they're sick and they have five billion plants that you don't understand, only the elders understand about… that's science. They also have different science about flowers; I am amazed how deep their knowledge is about plants and stuff, particularly for different medicines, for different types of sicknesses, and what plants go for each sickness, and you know they don't have any science background, it's all trial and error.*
>
> *SF: Is Tongan medicine and healing a Tongan 'science' or an Indigenous science?*
>
> *Grace: Yeah… that's Tongan science, but I am in a position where I don't trust it because I have been so westernised.*

This search for proof is somewhat contradictory, especially when the narratives describe the length of time a practice has been carried out:

> *[Tongan knowledge] has lasted for how many years, and it's based on a whole lot of things that have come to be, a whole lot of repetition that has been passed down. I feel that could be science as well, the only difference is that we don't*

> *know about research, we can't confirm for sure that this is definitely how this comes to this* (Setaita, KOTE).

These stories highlight confusion around what is acceptable knowledge or real scientific process. This confusion can only have negative impacts on academic achievement.

Collateral learning theory considers the cognitive issues that are created by learning about WMS and how non-western students deal with learning WMS to both fit into the western understanding and maintain their traditional conceptualisations (Aikenhead & Jegede, 1999)[35]. Using an anthropological lens allows an analysis of behaviour around learning science regarding culture that is useful for this research, such as autonomous acculturation and anthropological learning. Aikenhead (1996) described autonomous acculturation as a process where learners themselves choose what they will take from the culture of science without modifying their Indigenous perspectives. Although students are traditionally expected to assimilate into the sub-culture of science, autonomous acculturation enables them to expand, rather than replace, their conceptual thinking with aspects of WMS. For example, the most comprehensive explanation of Tongan science came from a participant who had shifted to Tonga during their secondary school education:

> *For Tongans, their science is knowing about the environment. There [are] different methods of farming, getting food, in Tonga we have farmers who have their recipe of how to plant stuff, they keep it to themselves, then they brag about how many crops they get using that technique. And ways of dealing with animals and how to take care of them, especially when it comes to disease, that might kill. Tongans tend to know more about that sort of stuff, animal-related science. When it comes to traditional herbs, there are a lot of plants in Tonga that we use, there is this plant that my mum always tells me to go and pick … the Nonu tree. We would use it for when we [get] diarrhoea or something in your stomach, you usually pound it and then drink. Another important one is the coconut, how we turn it in to oil. Another plant we pound and use for bathing, as our soap. We have many plants, that's what our science is about, and the fishermen know a lot, different areas to fish, local knowledge, knowing fish species. Learning how to cook is a science… (Inoke, KOTE).*

This narrative aligns with Ogawa's (1995) suggestion that experiencing a foreign culture can give perspective to an individual's own knowledge. What is particularly interesting about

[35] Although the psychology of learning is beyond the scope of this research, it is interesting to consider how the students are processing the science content and culture, as well as being a science learner. Therefore, some consideration of this concept occurs in the analysis that follows.

this example is that the 'foreign' culture in this participant's experience of another culture was of Tongan culture in Tonga. This story gives more support for the concept of the Tongan Educational Experience described in this research, and the process of sending Aotearoa New Zealand born Tongan youth to Tonga for their education and their identity.

There were discussions around how Tongan cultural knowledge, and by proxy, its science understandings, has changed from one with a heavy focus on faith to one that is more influenced by western thought:

> *Mata: Tongan science is more religion, its more godly to be honest... because now it's more westernised in Tonga, when I was raised it was already biology, chemistry and all that. If we go way back, they see Tongan science as more to do with God. The way I see it, science is how the body works, whereas if I ask my grandma, she would say Tongan science is God, godly work and what God says happens to the body. We also have the Tongan traditional medical treatments. For example, when my cousins would have things wrong with them, like a headache. I would see that, from a westernised point of view as something to do with the brain, tested by an MRI. Whereas she would go to a Tongan healer, and they would call spirits and things like that… that's how they see Tongan science, more to do with spirits and …Tongan beliefs.*
>
> *SF: Have you ever thought about Tonga having science?*
>
> *Mata: Never.*

This belief that Tongan science is not rigorously tested has motivated one participant to pursue a career in science that can determine if Tongan medicine does work:

> *Traditional medicine is an interesting thing, sometimes it makes you worse, sometimes it doesn't do anything. That's my reason to go into pharmacology, I could test it to see if it does work, that's part of the reason why I went into pharmacology (Mele, KOTE).*

A small number of participants in this group struggled to come up with a definition of Tongan science. However, when offered an example of how Tongan knowledge aligned with their definitions of science, it often triggered a dramatic change in the participant. They often came to see their traditional ways and practices from a completely different perspective, generally more positively and more respectfully:

> *SF: What about things like navigation, agriculture, fishing…?*

Setaita: Yeah! I would say that can be Tongan science, because its worked. I mean we've had these crops for how many generations? So, something must have worked, they must have known a process or something. And navigation… because they ruled many other Pacific nations, they would have known how to get somewhere, how to navigate or how to get through the seas or get to a place or go back to where they came from, and go back again, so they would've known where to go!

There were more examples of how reframing the importance of traditional knowledge triggered a re-evaluation of whether Tongan science existed; this indicates that participants carry this knowledge but unfortunately do not value it as highly as WMS:

SF: What do you think is [Tongan] science? …you defined science as 'understanding how things work.'

Malia: A lot to do with the land, observations… how stuff works, using what you are observing. For example, navigation, you learn about the stars, constellations, the currents, that's observations and how stuff works, and you use it to get to places and also agriculture… they don't do science stuff hard out, but medicines, herbal stuff, plants, remedies.

SF: Would you say Tonga has science?

Malia: Maybe not the same as in the western cultures, but …if we are going by that definition, then yes.

SF: Have you ever thought about that before?

Malia: Not really, no.

SF: Would you have ever considered Tonga to have a science?

Malia: No, to be honest …I have always known it as chemicals. We don't really do that.

SF: When you learn about those [Tongan] things, what do you think of them as?

Malia: Before now, not science, more ways of living, ways of doing stuff. That's about it, it's just stuff you do.

The Multiscience Framework (MSF) discussed in Chapter Two, acknowledges three types of science: personal, a unique perception of science which operates at the individual level; Indigenous, a collective perception which operates at the social or cultural level; and WMS, "one way of describing and interpreting natural phenomena" (Ogawa, 1995, p. 584).

Personal and Indigenous science are both informed by the cultural interactions and communication of that cultural group, while WMS is situated within the scientific community. All three of these perceptions are at play when learning about science, hence the suggestion to have a Multiscience approach to the teaching and learning process in science. One argument for this is that even if just considering the teacher-learner relationship, each of these actors would have a personal and corresponding Indigenous science. Even if Indigenous science perceptions are the same, 'personal science' may be different. This 'lens' highlights the potential diversity in the classroom and the need to consider these three science types and, therefore, the interaction and communication used about science (Ogawa, 1995).

Ogawa's discussion of the Multiscience perspective, including personal science, explains why many of the KOTE participants can discuss God in their definitions or understanding of science. Their personal and Indigenous science types accommodate different explanations of phenomena because they can understand different views simultaneously. It also clarifies why some KOTE participants had quite different understandings of TSK than others; there is diversity in the KOTE participants' view on what is TSK because their 'personal science' perception is unique to their experiences of TSK.

ANZE participants.

More participants in the ANZE group struggled to define Tongan science than in the KOTE group, to the point where some had no answer and were frustrated by the question, even after receiving examples:

> *Takai: Science is something that, to Tongan people, is, what's the word, it's… Oh man, that's a hard one! …Science to Tongans, is not something that is in their everyday life, is that what you mean?*
>
> *SF: If science is understanding, trial and error, working something out, can you think of something that is like a scientific approach or an understanding of how something works?*
>
> *Takai: I am getting there...*
>
> *SF: Like cultivation, when to plant things…*
>
> *Takai: They are good at that…*

Again, this reflects the westernisation of science described by the KOTE group. However, this is less surprising for participants who have been educated entirely in a western country such as Aotearoa New Zealand. For example,

> *SF: Do you see how navigation, cultivation, are science?*
>
> *Takai: I see how it is science, but hmm, yea, I never thought about it that way, you know? …But you are living in a western world, right? …You must adapt to the western way to learn science, but of course, I have my background in Tongan that can help, but the western world does dominate because that's how the world is, so…*
>
> *SF: Do you think you can learn the western way and equally value the Tongan way?*
>
> *Takai: You don't expect a yes or no aye, far out! I would say yeah, you can keep your Tongan values, but it could be affected sometimes. Far out! I never thought about it like that. Can you give me an example of how an application of Tongan science would be useful in the western world?*

Like the KOTE participants, there was also some commentary regarding the role of faith/religion in Tongan culture and how these affected ways of thinking in comparison to western approaches which require evidence,

> *Tongan science? …Tonga has a very strong foundation in religion… if you are comparing it to western science …what science is differs between Tonga and the western world, simply based on what they believe in. A lot of the answers that western science has for questions differ a lot from the way Tongans would answer it because of what they believe in …western science comes from things that are based on evidence… their evidence comes from the way that they have gotten to that answer or the way they tested it or investigated things. That's their evidence. Whereas Tongans, their belief in religion and things like that doesn't necessarily come from hard physical evidence but from a faith that they believe in… like their alternative medicines… they have certain therapies, and things that are not scientifically proven whereas in western medicine and science things are proven to work (Jake, ANZE).*

These types of stories often triggered a discussion that encouraged them to consider that these practices have survived over many generations could be proof of their validity, helping them to consider a different ontological position.

Most of these participants have not spent more than a few months in Tonga, if any time at all, so their exposure to Tongan cultural values and knowledge is based on what they

experience here in Aotearoa New Zealand and what they learn from their family and other networks. Participants in this group were frequently able to cite Tongan medicine as an example of Tongan science but often as their only example. Most reported their personal or family use of Tongan medicine but limited exposure to other Tongan science:

> *Avila: [pause] The only thing that comes to mind is our medicinal practices… they call my nana a baby healer, it's like fai'toa, but that means medicine thing… Yeah, their traditional ways of medicine, other than that, nothing.*
>
> *SF: What about navigation, planting, or construction, things like that?*
>
> *Avila: Oh, yes definitely, how people got to Tonga, navigation by the stars, and planting.*
>
> *SF: But if you thought about Tongan science, would those things come to mind?*
>
> *Avila: No, but I don't know the history, l thinks that's why the only thing that came to mind was medicinal.*

As noted above, experiencing a foreign culture enables individuals to perceive their Indigenous science more easily (Ogawa, 1995). Yet, migration has complicated the situation for these participants. Even though the ANZE participants identify as Tongan, their Indigenous science perception would be influenced by different social and cultural understandings than their counterparts in the KOTE group because they live in Aotearoa New Zealand. These experiences and the social and cultural perceptions of Tongans living here would influence the understanding of Tongan Indigenous science. Furthermore, their 'personal sciences' would have different influences.

When the ANZE participants did discuss Tongan medicine, they judged it against their standards of WMS. More often than not, the perceived simplicity of the Tongan approach meant it was not real science:

> *SF: If you were going to look at Tongan culture, and 'understand how the world works', can you think of things that would be like 'science'?*
>
> *Kava: With Tongan medicine. I am not too sure with science in general? It's based on history, it's something that they have tried, and they have seen it work so they continue to use it, they don't know in detail how it works, but they know it does work, yeah.*
>
> *SF: Would you consider that science?*

Kava: [pause] Yeah… a little bit? Based on my definition I gave you earlier, [pause] yeah, it's probably more simplistic. It's not detailed, but it is trying to understand that this does that, yeah.

SF: Before I asked you these questions, would you have considered Tongan medicine to be a science? Or that Tongans had science?

Kava: Nah… Probably because of how simple it is, I guess.

There are fewer examples of autonomous acculturation in the ANZE participant group. More of the narratives demonstrate aspects of assimilation into the subculture of WMS, evident in the dismissal of Tongan knowledge as worthwhile or scientific.

Unlike the KOTE group, the ANZE participants often included words such as 'superstition' when describing Tongan knowledge or approaches. Such terms carry negative connotations, strongly suggesting that they see this knowledge in a less than favourable light, or their manner implies this. For example,

SF: Do you think Tongans have a way of 'understanding the world'?

Laulea: Do you know what Tongans have? Too much superstition, it makes me crazy… it's because I have been doing science… like, you should drink this, you should drink that, no, you can't drink that, and I am like, do you have any research on this, you can't keep drinking random stuff.

In contrast, was the viewpoint that Tongan science had a more holistic approach and ability to accommodate belief and culture in a way that WMS did not:

Western science… they classify everything, bio, medicine, but… Tongan science you think about all of it together, it's not separated. Even with the human body, the mind and the body, in Tonga, that's together, everything is together, you can't split it up… it's more to do with our spiritual beliefs… there are deeper meanings to why we do things that might not be the same as western meanings. When you are Tongan and you are given Tongan medicine, your belief that it will work plays a role in that too, there might not be evidence to back it up like western science, but it works as well (Soana, KOTE).

This participant had spent time in Tonga as a child and often referred to the influence her family had had teaching her about different aspects of Tongan culture. This participant's 'personal science' perception is quite different to those of the participants that had not been to Tonga, or spent much time there, again echoing the concept that living in Aotearoa New

Zealand has changed Tongan perceptions of ISK (Ogawa, 1995). This narrative is an example of autonomous acculturation; the participant understands WMS but also maintains their Tongan perspective, understanding that their beliefs play a role in how well their traditional medicine works.

Westernisation and Tongan knowledge

Despite the focus on how colonialism has impacted on various aspects of the Pacific including economies and politics, "little attention has been focused on its impact on people's minds, particularly on their ways of knowing, their views of who and what they are, and what they consider worthwhile to teach and to learn" (Thaman, 2003, p. 2). This position can be broadened to include westernisation; the process whereby western culture and ideologies are adopted and replace local beliefs and ideas, in areas such as education. A recent concern around westernisation is the impact of globalisation and economisation of science knowledge from a western perspective. Rather than the more traditional view that pursuing science creates an opportunity to understand, capitalist agendas are seen to be driving a more corporate role for scientific knowledge (Ratuva, 2009). This situation has implications for different Indigenous cultures and their ISK and its inclusion in formal education systems.

The term 'culture' is omnipresent in education and education policy; yet, it can have different meanings to different audiences, making it essential to consider and define. As indicated in Chapter Two, this research uses a concept of culture that acknowledges that cultures are dynamic, ever-changing bodies of knowledge, ways, and practices that connect a group of people; understanding this culture can help student success. The anthropology of education maintains that a particular culture exists in any education setting, determining the teaching and learning processes, with attention to both implicit and explicit values and beliefs, the content delivered, and pedagogical styles of delivery and communication. Such a 'multidimensional' analysis recognises not only the influence of subject focus but also the hidden curriculum and the "unintended consequences of instruction" (Erickson, 2011, p.1). Culturally diverse classrooms can be problematic, with the term 'culture' often used to label students who are different, and therefore difficult, because they do not fit the dominant culture and are therefore perceived to be harder to teach (Erickson, 2011). This deficit

labelling of particular cultures has implications for learner identity as well as academic achievement and success.

According to Erickson (2011), it is important to consider culture relative to formal education in the following ways: the 'essentialising' of cultural groups; how, when and where the process of cultural transmission occurs; and the influence of communities of practice. Essentialising involves assuming that cultural groups are homogeneous rather than acknowledging that an individual's culture creates heterogeneous experiences. This perspective can result from using terms such as Pasifika, which attempt to homogenise whole geographic regions covering many different nations, cultures, languages, and histories into a single entity. Such assumptions of homogeneity can have implications for culturally responsive teaching practices; if we regularly overlook inter-ethnic diversity, it is more than likely we overlook intra-ethnic diversity too. For example, in Tongan society, individuals hold different social rankings, which are further complicated by the social context. This complexity can create very different cultural circumstances and experiences such as the type of schooling, for example, attending a small school in the outer islands or a big co-ed school in the capital city will be influenced by social position, opportunity and so on.

Erickson (2011) also stressed the importance of understanding that learning occurs not only in early childhood but across the lifespan. Thus, cultural change can happen within a generation, and parents can have quite different opinions and understandings to their children. Erickson's third point was that individuals are involved in different communities of practice in different ways rather than passively following one set of cultural rules. This complexity is especially true for migrant groups who are exploring different cultural rules from different generational understandings. These communities also morph and change as membership changes, influencing the habits, ideas, and practices of a community, which in turn affects cultural practice. When this perspective on culture is considered the similarities and differences in the participants' narratives discussed below make considerable sense.

ISK uses a particular cultural lens to interpret how the local world works (Snively & Corsiglia, 2001). For participants in the KOTE group, the impact of westernisation on IK is clear; the influence of western knowledge is de-valuing, and in many cases replacing traditional knowledge. For example,

SF: Do you think you have a good knowledge of Tongan medicine or traditional healing?

'Ana: No, it's a dying profession now, it would be hard to find, it's also something that's kept in a family, passed down from generation to generation and because of modernisation, no-one is into that anymore.

There was a general feeling by participants that Tongan knowledge needs to be preserved as the influence of westernisation was causing their ancestral ways to be lost:

SF: Do you think examples of Tongan knowledge in education would be useful?

Fatai: Yeah, they could make movies out of it, to encourage Tongan people to use their knowledge and their traditional ways. Even though the western side is getting stronger and stronger, they should use [it].

These stories echo Thaman's (2003) comments that 'western educational legacies' in the Pacific have devalued or suppressed IK, wisdom, and perspectives (Thaman, 2003). Some researchers (see Taufe'ulungaki,2003; Thaman, 2003), argue that the incompatibility of values emphasised by western education systems with those held by many Pacific communities, are contributing to the ineffectiveness of education in the Pacific region.

A few KOTE participants spoke about the wealth of knowledge that Tongans used to have and the detrimental impact of westernisation and modern technology on Tongan knowledge:

…the more ancient Polynesians had knowledge that could be attributed to science, such as reading the stars and sea navigation …we have been in Tonga for a long time. Polynesians, Tongans were seafaring people, but …the introduction of modern technology and everything, that's prevented them from the need to explore that… I know lots of people don't know how to read the stars. A lot of things about western ideology and modern society and technology have made everything else redundant… it is an aspect of science that has been lost. I believe that the older Tongans were enlightened people, but for some reason, it's lost… it's modern technology, and technology going [to Tonga] and no need to do things the way we used to before. Back then, it was useful because we were isolated, now it's easier to get around its redundant, nobody needs it (Mele, KOTE).

These participants are indicating the value they place on their IK and a desire to reclaim it. Finding opportunities and encouraging the embedding of IK and wisdom in the formal curriculum is one way to achieve this in Oceania. For example, despite the variability in their personal views of TSK, most KOTE participants described their personal and family use of

Tongan medicine, often on a very regular basis. This reflection prompted them to rethink the value of some Tongan knowledge, including occasions when Tongan medicine worked better than western medicines, and suggests that this knowledge should be valued not just for and by Tongans but in a broader context:

> *Fatai: …their knowledge of how the different plants work, the world should consider that. I don't know how they know it, but the Tongan traditional healing stuff works better, like in terms of boils and stuff, pimples… there are heaps of different plants and stuff… sometimes people, puke faka tevolo, when spirits are attacking people. They use the uhi stuff, and the spirit goes away, when you take it to the [western] doctors, they don't know what to do, they think it's some sort of depression, but then when the people use the leaves and stuff, the person gets normal, that's cool.*
>
> *SF: So [Tongan healing] works better in those situations?*
>
> *Fatai: Yeah.*

This TSK is relevant and, in some cases, more appropriate for understanding and interpreting local situations, such as the presentation of mental health illness. It appears that even though cultural change can occur quickly within a generation, particularly for migrant populations (Erickson, 2011), causing some knowledge to be lost, various cultural practices are still widespread enough to be excellent examples of how ISK can be utilised in science education (formal and informal) to make science relevant.

Ako.

Ako is the Tongan theory of education (Thaman, 2010; Māhina, 2008; Vaioleti, 2011). It refers to formal teaching and learning as well as nonformal and informal teaching and learning, which is predominantly carried out through observation, listening, and imitation (Thaman, 1995). Māhina (2008) describes the practice of Tongan education (*ako*) as the process of shifting the mind from *vale* (ignorance), to *`ilo* (knowledge), and then *poto* (skill), to both remove confusion and gain knowledge and skills for the greater good of society.

Although they did not use the term *ako*, the KOTE participants often indirectly referred to aspects of *ako*, describing a different way of learning in Tonga, namely informal situations of learning and teaching, occurring within familial relationships that don't require them to adjust to a new (western) system. For example,

'Ana: [TSK], in terms of health, Tongan medicine or Tongan medical practices, if you have pregnancies, I was delivered by a ma'uli, it's like a midwife, it's not based on western principles, it's a Tongan lady, and she does it because her mum did, her grandma did it, they learn by seeing it, by growing up in it, and that's how it's done.

SF: What do you think about that as an approach to learning?

'Ana: I think it's perfect… they are very passionate about it because of the ties that they have like their mum did it, their grandma did it, and they grew up in it. In Tonga …it's very specialised, that family does that, that family does that, I like it, they grow up in it, so they know, they don't have to navigate a system that is foreign to them.

They highlighted the positive aspects of this approach, particularly how they would benefit from this style of delivery and learning opportunity relative to their experiences of the western way of formal education. For example,

SF: You mentioned your family teaches you things and your grandparents… what's the best way for you to learn?

'Ana: Growing up with it, having that access to your teacher and being a student at the same time. It's a way of life, you don't see it as learning thing, that that structure or model. I would prefer that, I wish they had Tongan doctors and to be taught in that way, to grow up into it.

Tongan science knowledge in the curriculum

> …the decolonising Pacific Islander inevitably returns to pre-contact Oceania to reimagine the unity and connectedness of things (Subramani, 1993, p. 27).

As outlined in Chapter Five, the Aotearoa New Zealand curriculum is dominated by WSMK and the influence of westernisation and globalisation means the place for ISK is unclear, ignored, de-valued, or de-prioritised. The next section shares examples of how this research's participants experienced ISK in their formal education and their thoughts and reactions to TSK.

KOTE participants.

The KOTE participants were more likely than the ANZE participants to have experienced examples of Tongan science delivered in a course or programme that they were studying,

usually during their secondary schooling in Tonga rather than secondary school or university in Aotearoa New Zealand. Most schools in Tonga did deliver Tongan science content, often in a course (i.e., Tongan studies) that focused on aspects of Tongan history or culture, never in a course with a science focus. Topics included aspects of navigation, cultivation, and construction:

> *SF: Have you ever had any [Tongan] knowledge taught to you in your formal education?*
>
> *Alau'ua: Yeah, cultivation. We get taught that in Tongan studies… how the plants, and the seasons, when it's good to plant certain crops or… that's science, navigation, social science, we get taught about…*

Incorporating TSK into the formal Tongan curriculum advocates for Indigenous and local knowledge and wisdom. It encourages students to value their traditional ways of knowing; for example, one participant described how learning about traditional construction in their primary school in an applied way was an enjoyable way to learn. Upon reflection, it also made them realise the value of this form of traditional knowledge because they were demonstrating its complexity in a practical setting:

> *Vaea: We learnt [traditional construction] when we were in primary, how to make Tongan houses, we figured out how to make it stand up, look like a house.*
>
> *SF: How was that?*
>
> *Vaea: It was hard to get it up, but you start to think about how Tongan people did it back without any knowledge, you start thinking about how they did it… it was fun.*

This example demonstrates how local science can be legitimised, creating ways to enculture Tongan students into the subculture of Tongan science. Using relevant examples or using knowledge that demonstrates how this knowledge is, science reduces the amount of border crossing these students have to do. This narrative contains an example of science that would be experienced in these students' everyday culture, making it accessible and understandable.

Another participant described how their quite extensive exposure to Tongan science in various ways in their secondary school education in Tonga had helped them to understand concepts better and kept them interested in learning about science:

> *In biology [in Tonga], when [our teacher] would go into the plant section, they would refer to us going and planting stuff in the field, and they would compare it with something that they were trying to teach, make analogies to help us understand what they are trying to teach us… most of the boys identified with that sort of stuff, they knew, they understood. When we were classifying different plants, I remember them telling us about the coconut tree, and trying to classify that. They would tell us the scientific names, and they would use other plants as well. When it came to classifying stuff, they would use Tongan animals, there is a flying bat in Tonga, they would use that when it came to that section… because we already knew about it, it helped us to understand something from the textbook (Inoke, KOTE).*

Thaman (2003) argues that it is the responsibility of educators to ensure their students can critically analyse their experiences. She considers it essential for them to understand the impact of colonisation and the globalisation of a dominant western viewpoint on their Indigenous education system and experiences. One way to do this is to include ISK in the formal curriculum, in this case, TSK, to counter the 'educational hegemony' of WMS. It also would help address the potential rejection of IK and personal culture that may come while negotiating the cultural borders between ISK and science. This inclusion can lead to the achievement of autonomous acculturation (Aikenhead, 1996) because it would provide opportunities for students who are not of the dominant culture to reflect, engage, utilise and value their ISK as evident in the above story.

When it came to the university setting, most of the KOTE participants' examples related to navigation, often delivered as a pan-Pacific practice rather than a specifically Tongan knowledge[36]. More often than not these examples only occurred in the context of the university foundation/bridging programmes, and never in the years that followed: *"In [foundation/bridging], navigation and coming from wherever PIs come from, navigation through the Pacific, that kind of exposure, it was very minimal but ever since, no" ('Ana, KOTE)*.

Most participants in the KOTE group indicated that it would be helpful to include Tongan science in course content as it would make it more relatable and relevant to them, particularly in Aotearoa New Zealand. For example,

[36] There was some discussion about exposure to other forms of IK during the participants' university courses, but this was not specifically Tongan. However, it does highlight that there is space for ISK, so suggesting the need to increase it to help engage and retain Tongan students does not seem unattainable.

SF: Would it help if there were examples from Tongan culture in your education?

'Ana: Definitely yeah… [Aotearoa New Zealand's teachers'] stories are irrelevant to me and, therefore, my engagement, urgh! I am so detached from this culture, I need to be able to relate to my teachers, I need to be able to relate to what I am studying, but I am not…

The cultural relevance of the curriculum is an important factor in the retention of Indigenous students through school and university (Fleming & Southwell, 2005). Another essential part of education for many Indigenous cultures is the development of a relationship between those involved; with their teachers and other students. This relationship needs to happen before effective learning can begin (Thaman, 2010). One participant described how the opportunity to describe their experiences of Tongan medicine changed the dynamic of the [university's] small group learning environment for them, particularly their relationships with their peers and teaching staff. For example,

In [one university course] we talked about Indigenous medicine, spiritual healing, cultural medicine, those kinds of things, this is the first time I ever got to talk about it… It was cool, like other people are more interested in my culture, and what I had to say, and I never had that before. They came and asked me questions, a lot of questions were asked about what medicines I took from my grandma… my tutor, as well, they were interested (Naua, KOTE).

The benefits of understanding their culture also included extended to how having a good understanding of Tongan knowledge could strengthen their relationship with their patients. They felt this shared familiarity meant they could relate to the older generation:

SF: Do you think it would be useful to refer to Tongan knowledge?

Mata: For me, because I am passionate about working with Tongan patients, yeah. I am passionate about Tongan health, and Pacific health in general, so most of our patients, a lot of them would be the older generation and a lot of their thinking would be more in terms of Tongan knowledge and back in the days, you know history and things like that. So, it would be a good way to interact with them, to relate to them and where they are from.

ANZE participants.

In contrast, none of the ANZE participants had ever experienced any direct references to Tongan science in any of their formal education other than the pan-Pacific navigation example delivered to those participants who completed the foundation programme (see

above). Most felt that it would be useful to have exposure to Tongan science in this context because they could help their understanding and it was relevant to them: *"It would be useful, because it would be your understanding, like how we would see it, it would make it so much easier to understand things"* (Sina, ANZE). Some participants suggested that presenting this knowledge in this context would validate it:

> *It would be useful to be aware of Indigenous views of science… for science even in high school it would useful to be taught that so you could register that that is science. A lot of us, we grow up knowing these things and thinking its superstitions, but they are what my mum and my grandma believe to be science without saying that they think its science (Lashandra, ANZE).*

Like the KOTE participants above, this narrative also supports the need to hear about ISK in a formal education setting so it is validated. The use of the term 'superstition' rather than science indicates the rejection of traditional knowledge that occurs when negotiating cultural borders between ISK and WMS (Aikenhead, 1996) is a reality for Tongans in Aotearoa New Zealand.

Furthermore, as Thaman (2003) suggested, the inclusion of Tongan examples would give a broader perspective to science education:

> *SF: Would it help you if people used Tongan examples when they are teaching you science?*
>
> *Soana: new examples are good… more than western, because it brings a whole other world, more perspectives, you might find something useful.*

This position aligns with Ogawa's (1995) emphasis on Multiscience and that all groups have science. Another strong theme was the suggestion that including information about the Pacific rather than other international examples would help students become more aware and more respectful of each other. For example, "*It would be good if we could all understand everyone's cultures… people [should] be taught about cultural tolerance, where people can understand everyone" (Laulotu, ANZE).* Like the KOTE narratives, these stories echo the importance of diverse understandings and offer suggestions for how, and why, we must include ISK in the formal science curriculum.

Implications for science teaching

Embedding ISK in the formal curriculum of higher education institutions can enrich the student experience insofar as it provides diverse understandings, perspectives, and wisdoms (Thaman, 2003). Opportunities to learn about the ways other people understand or perceive things can improve relationships and how people treat each other in society, and demonstrates a valuing of different knowledges. Indigenous worldviews are often an "inclusive and holistic way of thinking [that] champions stewarding nature, participating in community, and valuing interpersonal relationships. It compliments beliefs in rational objective thinking, suspicion of emotions and feelings, material productivity, and personal autonomy" (Thaman, 2003, p. 12).

In this section, I offer tangible ways ISK can be embedded, and some student response to these attempts. I think it is essential to address the belief that there is one particular way to do this; in my experience, the educator should consider their context and what is appropriate, once they know what they are doing or are receiving guidance. The most important part of this adjustment process is the educator's commitment and engagement in something that will probably cause them to question their ontological positioning. Nevertheless, reflecting on how and why they do things in their teaching and learning spaces is essential to improve their teaching and learning practice.

Valuing Oceanic knowledge.

Hau'ofa's (1993) presentation of a 'sea of islands' rather than 'islands in a far sea' effectively counters the belittlement of the Pacific islands and the 'smallness' of their contribution to the world. He argued it was only possible to maintain this viewpoint if the terrestrial environment is valued more highly than the marine, and by devaluing the skills required to flourish in the marine environment because they are not familiar, understood, or shared by those who inhabit large landmasses. He asserted that this narrow view is informed by a particular economic and geographic perspective which is one that discounts,

> the kind of world that bred men and women with skills and courage that took them into the unknown, to discover and populate all the habitable islands east of the 130th meridian… [are] real feats that could have been performed only by those born and raised with an open sea as their home (1993, p. 10).

I was already aware of the great skill and expertise required to traverse the Pacific Ocean and felt I did not hold a deficit view of Pacific knowledge. Yet, one aspect that particularly struck me was Hau'ofa's (1993) realisation and admission that he was "so bound to the notion of 'smallness'" (p. 5) perpetuated by western perspectives, that he had been unable to see that by "propagating a view of hopelessness [to his students], [he] was actively participating in our own belittlement" (p. 151). During my critical self-reflection, I realised that I too had been bound to a notion of smallness. I was perpetuating the dominance of WMS in my teaching and learning spaces, even though I worked in equity education, was well-versed in Pacific history and achievement, and knew the importance of reflecting on my style of delivery and relationships with Pasifika and Māori students. I realised it was easier for me to align with the belief that my focus was to deliver very important WMS science content to my students rather than challenge my unconscious belittling or ranking of other knowledges. I know many science educators who avoid rigorous reflection and personal challenge by hiding behind a fear of doing the 'wrong' thing. This avoidance becomes their safe space rather than the more difficult acknowledgement that their defensiveness relates to a lack of cultural capital and comfort in diverse cultural settings. In Hau'ofa's (1993) words, "[b]elittlement in whatever guise, if internalized for long, and transmitted across generations, may lead to moral paralysis, to apathy" (p. 6) or, in this case, complacency in the belief that WMS is superior or better.

Science educators, like any experts, are expected to know what they are doing, so to admit ignorance or a lack of skill is no doubt hard and can feel undermining and expose an uncomfortable vulnerability. However, if someone of Hau'ofa's standing can admit that he too had to make such a deep internal change, it felt safer for me to recognise and express my vulnerability and ignorance. I wanted to confront this idea of smallness and how I perpetuated it, especially as "the idea of smallness is relative; it depends on what is included and excluded in any calculation of size" (Hau'ofa, 1993 p. 6). Although Hau'ofa was originally referring to the size of landmass and perceived economic and cultural contributions, I feel smallness also relates to the perceived contribution of ISK, particularly how the inclusion or exclusion of ISK informs our ontology and how we consider various phenomena.

Using assessment to embed Indigenous science knowledge.

While preparing a literature review for my doctoral enrolment application, I noted the paucity of published examples of work describing TSK in any formal science education. I also noted that published examples of ISK being used in education in the Pacific, are generally hard to find outside of articles[37] on sustainability, marine ecology, and navigation. It concerned me that what I knew is a rich cultural knowledge and history appeared to be narrowly engaged with, or overlooked entirely, by science educators. This situation made me think about how I could enable my students to be exposed to or share their ISK in my classrooms, and how ISK could be included rather than excluded. This shift would attempt to bring a focus on the realms of the actual and the real as critical realism urges; it would also broaden what is noticed in the empirical realm because it would be in the formal science learning space.

One example of how I have since changed my practice relates to the inclusion of ISK through assessment. I teach and coordinate a course that focuses on cell biology, human anatomy, and physiology, not typically topics that reference ISK. During the interviews for this research, it became clear that ISK had been largely absent from the formal science education of both participant groups. The ANZE participants had had very limited if any, experience of ISK. The KOTE participants were more likely to have had some experience of ISK during their education in Tonga, although it was not on par with the 'formal science knowledge' presented in classes. The following story describes what it means to (not) see their Indigenous selves' as an aspect of their formal science education:

SF: Have you had any references [to TSK] in any of your formal education?

Grace: Nope.

SF: Informally?

Grace: [pause] At home? Yes, not necessarily here in New Zealand though. When you go back to the Islands, you get taught the Island way, 'cos there is that constant struggle of what you can and cannot do here in New Zealand, in terms of our traditional practices, [if] it clashes with the western views and western society, so there is a tension between being Tongan but with the, [pause] is it acting Pālangi, with a Tongan brain or something like that? …Like, you've got to blend in

[37] I acknowledge that not all successful education practice is published and that publication itself is problematic, but it is a useful medium to identify what is happening in a particular field and, in this case, region.

> *with the rest of society here in New Zealand, especially in science, you've got to blend in and learn all their terms and learn everything and then go home but you can't put that in practice 'cos you got your own [traditional Tongan things] you have to follow.*

When considering my literature review experiences, such comments were not surprising. Nonetheless, the rarity of published examples of ISK in formal education in the Pacific resonated strongly with me. How could I enable my current students to express their ISK so that it was empowering, relevant, and visible? As I focus on cell biology and anatomy and physiology, my courses originally had very little Indigenous science content. In response, I began to develop an assessment that would increase student exposure to ISK, both their ISK and that of other Indigenous peoples. I now ask students to describe Indigenous healing practices they may have been exposed to, or currently, use, that relate to one of the organ systems as per the WMSK view of the organisation of the human body. For example, considering traditional methods of wound healing alongside the integumentary system. This assessment triggers many questions for the students, particularly how to reference unpublished ISK and the 'validity' of their examples. They are encouraged to discuss these concerns personally with me rather than over email, creating an opportunity to *tauhi etau vā*, manage our personal relational space[38], while unpacking what ISK is and whether their ISK example is 'real' knowledge.

For example, my students usually struggle with the idea that they do not need to reference their ISK other than by naming whom they spoke to, or if it was a personal experience, they could use the first-person narrative. Insisting on a published source echoes the struggle for many of my research participants to determine, what is TSK and how it ranks in comparison to WMSK, as the following excerpt illustrates:

> *SF: Do you know anything about Tongan science? Like a body of knowledge [or] practices or approaches in Tongan culture that you would consider to be science?*
>
> *Sina: Um, [pause] not really, I guess 'cos I am so used to seeing it 'westernly' I find it difficult to…*

This assessment now provides an opportunity for students to reclaim and (re)present IK. They are also encouraged to consider the relevance and place of ISK relative to WMSK in the

[38] This concept acknowledges the importance of maintaining personal relationships, with the understanding that maintaining a good relationship is not an easy thing to do and requires work.

programme. To ensure they see how valid I consider ISK to be, over half of the assessment marks are focused on the knowledge they share; the WMSK component is worth less than a quarter of the marks.

Identities are formed by what students bring with them to the classroom but also what the classroom, school, and educational contexts suggest to them about their academic ability, teacher expectations, and their academic potential (Carlone & Johnson, 2007; Samu, 2015). I wanted to foster their appreciation and pride in their ISK, worldviews, and experiences. Arguably, being able to be proud of their culture, knowledge, and values is an important way for Indigenous students to develop a positive science learner identity.

To evaluate whether this assessment is achieving its goal, current students completed an anonymous online survey asking them about the assignment. Overall, the feedback was positive, with students describing it as fun and helpful, *mana*-enhancing, and engaging. They also liked having the opportunity to engage with their culture and family knowledge and learn more about their ISK. They felt the assessment empowered them and made them feel proud. All ideas align with my aim to create space and opportunity for them to develop a positive science learner identity that embraces their indigeneity.

I use this assignment as an example of how science educators can make simple changes that will have far-reaching consequences for their Indigenous science learners. It also provides a way to get teachers to trust that Tongan (and other) cultural knowledge is useful in teaching and learning spaces, a struggle noted by other researchers (for example, Fa'avae, 2019).

Considering the stratified ontology of critical realism, I believe this assignment encourages a recognition of the history and place of ISK in our lives now. It also encourages considerations of ISK's current position and how practices and processes in the past and present, such as colonisation and globalisation, have informed this position. Exploring ISK in this manner also exposes students to the concept that knowledge is fallible; they are encouraged to consider how WMS and its focus on positivism have taught them to conflate what is known with what is. This is evident when students ask if they can consider *karakia* or prayer as a form of healing – my answer is of course, since you do not need to prove how

your example works scientifically, any practice that their family utilises is real; the proof is that this practice is continuously used, rather than a published reference.

Relationality acknowledges the importance of connections to non-living entities. This assignment allows students to demonstrate their connections spatially and temporally by connecting to their ancestors through using their ISK or a particular practice, as well as connecting them to their homes and family who might be geographically distant from their place of study. It also builds connections between family members, encouraging students to realise the valuable knowledge their families have. This assignment has often connected students to their family or culture in ways that had not happened before. Multiple sciences are also presented; the cohort diversity expands the range of ISK that is seen, with examples from across the Pacific and within Aotearoa New Zealand.

Concluding comments

Thaman (2003) argued the importance of decolonising education. The decolonising lens applies to this research as it argues the same points: the importance of acknowledging the dominance of western philosophy, content, and pedagogy in the Pacific; the value of understanding Indigenous ways of viewing the world; and the need to consider culturally inclusive and gender-sensitive perspectives. Incorporating Pasifika knowledge and worldviews into the formal curriculum and pedagogy recognises the value of Pasifika perspectives (Thaman, 2003; Vaioleti, 2011). It also aligns with the desire of the reformed NZC (2007) to allow all students to be able to learn and express their values.

When looking for ways to improve teaching and learning, it makes sense to utilise the culture of the students who are struggling in a system dominated by another worldview. As science education practitioners, we need to substantiate and build on the "validity of students' personally and culturally constructed ways of knowing" (Cobern & Aikenhead, 1997, p. 13). This perspective suggests what educators might do better when designing and directing initiatives to enable Pasifika students' successful navigation of university study without a need to compromise their learner identity. It is evident from the quotes above that acknowledging and including Pasifika knowledge is one way to counter the dominance of western content and pedagogy in the education of Pasifika. Creating these opportunities provides inclusive learning environments (secondary and university) that can potentially

increase the achievement of Pasifika students by increasing their engagement and enjoyment of what and where they are learning.

Chapter Six – Education in the Kingdom of Tonga

This chapter explores the experiences of the participants who spent part of their formal education in Tonga (indicated by the acronym KOTE), beginning with a brief history of the introduction of western education to the island nation. A key aim of this research was to determine which teaching and learning practices have influenced Tongan science learners with the premise that elements of Tongan customs and culture would have had some bearing on their studies. Thus, the rest of the chapter contains stories from the KOTE participants, themed to provide perspectives and understanding of how science is taught, including stories about the teaching and learning environment. It also presents and explains the phrase, 'Tongan (education) experience', including some of the myths about education in Tonga.

Education in the Kingdom of Tonga

Formal institutionalised education (schooling) was introduced to Tonga during the early nineteenth century by Christian missionaries who prioritised and promoted elementary education so Tongans could read the Scriptures the missionaries were espousing (Lātūkefu, 1974). Early attempts to open schools on the outer islands to encourage Tongans to learn to read and write did not last long because of local opposition. Later efforts were more successful in Nuku'alofa in 1828 (Lātūkefu, 1974; Thaman, 1995; Fusitu'a & Coxon, 1998), a school book was printed in 1831[39] (Lātūkefu, 1974) and education became compulsory in 1862 (Coxon, 1988). This system established one of the earliest compulsory primary schooling programmes in the world, well supported by Tupou I. During his reign, formal education based on western knowledge was considered necessary to understand and participate in the world, but it was not seen as superior to Tongan knowledge (Fusitu'a & Coxon, 1998). Instead, it has always been valued to gain knowledge and independence, enabling the educated person to help their family through employment and upward mobility, and increased status (Mara et al., 1994; 'Otunuku, 2010).

[39] Becoming literate in English rather than Tongan would understandably have been a more complicated process, so subjects were taught in Tongan requiring the supporting printed resources to also be in Tongan (Lātūkefu, 1974)

The hierarchical structure of Tongan society, to a large extent, determines the transfer of knowledge according to hereditary lines. Like most Pacific societies, the traditional objective of education was to maintain social relationships and systems and transfer values, beliefs, and knowledge between generations (Mara et al., 1994). In Tonga, the '*eiki* (chiefs) determined who could possess which knowledge, an example of how social class determined knowledge gained (Fusitu'a & Coxon, 1998). However, the provision of education in this formal institutionalised western way allowed *tu'a* (commoners) to access knowledge, and subsequently, social and political power, resulting in social mobility.

The first secondary school, Tupou College, was founded in 1866 by Rev. J. E. Moulton[40] to educate Tongans, particularly young chiefs, for government positions (Lātūkefu, 1974). The system was intended to be comparable to other international standards of education, aiming to achieve 'academic parity' with grammar schools in England (Coxon, 1988). The missionaries also insisted on equality, an unusual occurrence in the highly ranked Tongan society; Tupou College accepted both women (from 1876 onwards) and *tu'a* if they could attain entry standards and afford the fees (Hingano, 1987). By 1868, day-schools were teaching "religious subjects, history, geography, arithmetic and English, and philosophy, astronomy, geometry, algebra and physics" were taught in the training institutions (Lātūkefu, 1974, p. 77). Chemistry was offered by 1869 (Hingano, 1987); it is noted here explicitly because of this research's emphasis on science and to indicate how long some Tongan schools have taught chemistry. Academic achievement was extremely important, and the academic focus was recognised by the type of employment of graduates, either in the government or the church. However, there were some who considered the curriculum to be too presumptuous for Tonga and too complicated for the Tongan technology that was available (Hinango, 1987), with claims that "Tongans were not ready for such an education and that it was irrelevant to Tongan society" (Coxon, 1988, p. 86).

The missionaries continued to expand the formal school system; in 1876, an Act of Parliament made education compulsory for those aged between seven and 16 years old (de Bres, 1974). During Queen Sālote's reign, the Education Act of 1927 made education mandatory so that,

[40] Moulton was extremely influential in Tonga, and some of his influence continues today. For example, his numerical notation system to teach formal music training is still used.

> every child of not less than six or more than fourteen years of age living within a distance of two miles from a government primary school shall attend that school or some other public primary school unless the child has passed Class 4 (de Bres, 1974, p. 22).

Formal education in Tonga, although non-secular, has always been closely tied to religion (Tongati'o, 1984). Yet, the state gradually started to increase its role in the 1970s and 1980s:

> It has taken nearly one hundred years for education to become unified in its objectives, as indicated by having standard final examinations towards which all secondary students work. Increasingly, the government is getting more involved with the development of education in the various sectors, church and private (Tongati'o, 1984, p. 29).

As explained in Chapter One, today, there are four sub-sectors in the current education system, and education is compulsory between six and 18 years old; in 2016, 94.5% of 5-14-year olds and 71% of 15-19-year olds were enrolled (Tonga Statistics Department, 2017). Traditionally attendance and achievement in Tongan education have been high; Tonga has a history of having higher rates of enrolment in upper secondary education than other countries in the Pacific (UNESCO, 2008). However, there is limited information specifically on science education in the public sphere. Therefore, this research provides valuable insight into formal science education in Tonga for science educators who have Tongan (or Pasifika/Pacific) science learners to consider in their praxis.

Tongan cultural values, customs, and knowledge.

A key aim of this research was to determine which teaching and learning practices have influenced Tongan students with the premise that elements of Tongan customs and culture would have had a bearing on their studies in science. Similar impressions have been recorded previously by Tongan researchers, for example, Manu'atu (2000), who stated, "Tongan language and cultural practices are inseparable from understanding Tongan student learning" and can offer pedagogical suggestions to positively influence the Tongan student's learning environment (p. 182). The prevailing view of the KOTE participants was that religious beliefs and *faka'apa'apa* (respect) influenced their science education.

Although never colonised, the Christian beliefs brought by the early missionaries have strongly influenced Tonga and Tongan culture. This influence is still evident in the current formal education system and the contemporary demonstrations of Christian values that have

been "internalised as part of Tongan custom" (Fua, 2007, p. 677). Religion is influential in most Tongan schools and has provided support to many of the participants in various ways:

> *…at the school I went to they emphasised praying, being able to pray by yourself. When it came to hard times, you would pray, it would motivate you to study. Here, when it came to tough times, I would pray before exams… they taught us three things, to identify with our spiritual side, our physical side, keeping fit, and education-wise (Inoke, KOTE).*

Religion can influence what is taught or how students and teachers respond to it:

> *Talking about evolution in science makes you want to stop doing [science] [laugh]. Sometimes, church plays a role and makes you want to do science. What I like about studying it, is how incredible God has created everything, but when it comes to evolution, it makes [it]… harder to engage, because the whole church thing in Tonga is strict when you start talking about it, and you hear the teacher talking about it, and you start to think if you want to study it (Vaea, KOTE).*

Evolution is known to be a difficult topic to teach in science because it espouses a view on the origin of life that is generally contentious for those with strong religious beliefs (Reiss, 2010). This tension is particularly true for some Christian based beliefs (Yasri & Mancy, 2012), which are the most commonly held in Tonga. Religious belief is one of the main influences over a learner's acceptance or rejection of evolutionary theory (Yasri & Mancy, 2012), which is an essential topic in most biology courses. The frequency with which the KOTE participants described their experiences and thoughts regarding learning evolution would suggest that this is also true for Tongan science learners.

The same participant also described how their teacher suggested they cope with the inherent conflict between science and religion: *"I remember my teacher in Tonga, when we were up to the evolution topic, [said] study it, just don't get it into your head, [you] just have to know it…" (Vaea, KOTE).* A teacher's religious beliefs have the potential to impact on their teaching performance, their pedagogy, and their students' learning (Mansour, 2008). The Tongan term for teacher, *faiako*, literally means 'to make learning'; the English term 'teacher' means someone who 'instructs' or 'imparts' their knowledge or skills (Thaman, 1995; Vaioleti, 2011). According to Vaioleti (2011), *faiako* also suggests an active co-creation process between teacher and students and a role in guiding the education process and pathway. The *faiako* in this narrative demonstrates a strategy for students to address learning about evolution, exhibiting how *faiako* can use their wisdom to assist student learning (Vaioleti,

2011). Interestingly, rather than encouraging them to shut down or refuse to learn about evolution as might be expected, their *faiako* advised them to consider the bigger picture. This stance is a useful perspective to create, particularly if a student with strong beliefs wants to pursue science in a western education system such as Aotearoa New Zealand, or one that is heavily influenced by western pedagogy such as Tonga; it demonstrates one way of how to accommodate religious beliefs alongside the pursuit of science knowledge

Controlling the Learning Environment.

Although the western influence on education in Tonga is acknowledged, according to the KOTE participants, Tongan values and culture are still evident in the Tongan education system: *"at [my school] …they tried to be as westernised as they could in terms of teaching… but there is a mix of that and a whole lot of Tongan cultural stuff"* (Setaita, KOTE). Most participants suggested that the way that Tongan values and culture are most apparent is through *faka'apa'apa* or the systems of respect in the classroom and broader learning environment:

> *…because the teacher is the authority in the class and that person is older than us, we have to respect that person and what they are telling us to do, and we have to do it… it's a respect thing… having respect for the teacher, you are doing the work, actually valuing the topics (Setaita, KOTE).*

Faka'apa'apa is a core value of Tongan culture*; anga faka'apa'apa* means respecting and being deferential towards others as their social ranking necessitates (Vaioleti, 2011). *Faka'apa'apa* is *"*not compartmentalised as one aspect of being, but rather it is a philosophy that guides a Tongan's life*"* (Fua, 2007, p. 679), and *"*an unwritten social contract that all Tongans aspire and adhere to in various degrees and contexts… [it is a] shared understanding that this is a relational social contract between two people… demonstrated through behaviour [and] speech…*"* (p. 677). Fua (2007) argues that *faka'apa'apa* is a critical element of the Tongan conceptualisation of social justice because it determines how relationships work, ensuring the intent to respect and honour each other and a focus on the collective. This focus emphasises interdependence and social cohesion rather than individualism, while simultaneously acknowledging individuality and difference through the ranking system inherent in Tongan society. She also argues that this Tongan form of social justice has a slightly different emphasis than others because the collective is already so crucial in Tongan

culture, as are relationships which are "essential social capital for Tongans and Pacific people" (p. 678). Acknowledging the Tongan perspective on social justice is essential for this research because it situates the drive to achieve equity in education for Tongan students within a context that understands Tongan customs, culture, and identity.

Often when the participants moved to Aotearoa New Zealand, they were surprised by the contrast in teacher-student relations between the two countries:

> *At school in Tonga, the teacher is always right. But when I came here [to Aotearoa New Zealand], the girls talked back to the teachers, who didn't do anything about it, when they said you had to do something, the girls disagreed, they would win, and the teacher would lose and I found that amazing, just the cultural shock… [its] more liberal here [and] more restricted in Tonga (Mele, KOTE).*

The KOTE participants often talked about how strict the teachers were and how tightly controlled the learning environment was in Tonga. For some, this combination encouraged them to do their work, for others it created a more respectful learning environment:

> *…the class here is undisciplined, so noisy, compared to the school I went to [in Tonga], [it had] good discipline, everyone respected the teachers… I think it's better. I liked it way more; everyone respected each other (Inoke, KOTE).*

In Tongan culture, it is essential to respect authority; any behaviour that contradicts authority is considered disrespectful and disobedient. In this story, the way the Aotearoa New Zealand students engage with their teachers does not demonstrate a way of behaving that is "honouring and protecting the dignity of the other" (Fua, 2007, p. 677), confusing this participant who has been raised to *faka'apa'apa* their *faiako*. This confusion probably reflects the different educational *vā* (space) created by being outside of Tonga but may also be because the impact of globalisation on Tongan cultural values is more evident in Tongans residing in Aotearoa New Zealand.

Manu'atu (2000) indicated that for Tongan achievement to be improved, Tongans need to be learning in "specific, suitable and appropriate contexts" (p. 19); perhaps the tightly controlled learning situation described here is one of those contexts if it is positive. Some KOTE participants implied that a more disciplined environment might increase achievement:

> *In Tonga, when the teacher says something, you do it, you don't talk back. If you do, you get in trouble. In New Zealand, they are very disrespectful. I feel people in*

> *New Zealand, me too sometimes, we aren't grateful for the opportunities. I think it's a good thing to be strict because it's not a bad thing to make sure kids are learning (Malia, KOTE).*

Manu'atu (2000) also stated that *"*where and how to draw good pedagogical ideas from the Tongan language and culture is a creative task for Tongan educators to pursue*"* (p. 28). This research would argue that Tongan students also play a role, particularly those who have experienced both education systems. Importantly, the KOTE participants provided numerous examples of how Tongan knowledge and culture had been used to teach them science in Tonga; all of them useful suggestions for science education. Mostly, these suggestions recognise the concerns raised by different Pasifika educators that the educational environment must reflect both Pasifika and western pedagogies (Taufe'ulungaki, 2003; Nabobo-Baba, 2006)[41].

Science teaching in the Kingdom of Tonga

There is limited literature on teaching and learning in Tonga, even less on science teaching and learning. One example, a research project conducted on science education in Pacific Island countries (including Tonga), observed that most classes were:

> largely teacher centred and relied primarily on direct teacher instruction. Students were very compliant and nearly all students appeared on task all of the time. Students very rarely asked questions of their teachers about lesson content and at no time questioned the authority of their teacher. Likewise, when students were questioned by their teacher, they remained silent or answered very quietly despite teacher attempts to coax answers from them (Delmas, 2003, p. 2).

Also, large class sizes or a lack of laboratory equipment limited the practical side of teaching and learning science, so most practical activities were demonstrations by teachers. Furthermore, many teachers were concerned that students were not achieving as well as expected *"*despite their students' hardworking and conscientious approach to their school work*"* (Delmas, 2003, p. 3).

Although providing some information about the teaching and learning in Tongan science classrooms, Delmas' work is limited to a general description of the delivery of science lessons in the Pacific region over ten years ago. It also avoids considering resource

[41] Further definitive examples are demonstrated in Chapter Four - Indigenous Science Knowledge.

constraints in the Tongan education system or that, as mentioned previously, historically, informal teaching in Tonga has predominantly used observation, listening, and imitation.

Many developing countries continue to use teacher-centred practice rather than learner-centred learning (Guthrie, 2011). Guthrie describes the 'Progressive Education Fallacy', the *"*false premise that progressive, enquiry teaching styles are necessary to promote intellectual enquiry skills among primary and secondary students, in this case in non-western, especially non-Anglophone cultures*"* (p. *xxv*). He suggests that although many western countries consider *"*formalistic ('teacher-centred', 'traditional', 'didactic', 'instructional') pedagogy*"* as inappropriate pedagogy, it is appropriate in many countries (p. *xxv*). The Tongan science learners in this research refer to a system which emphasises didactic teaching; although critiqued by them, it had elements that worked for Tongan science learners. Guthrie suggests educational "progress is not necessarily a case of moving to a progressive style but can well be a case of improvement within a style (e.g., upgrading formalistic teaching)*"* (p. *xxv*). I agree and propose that formalistic classroom practices such as didactic teaching may be the teaching and learning practice that best supports science learning in the Tongan context. Furthermore, the desire to be 'progressive' may remove the opportunity to influence didactic methods with Pasifika perspectives to address underachievement.

More recently, Bay et al. (2016) have examined the importance of developing scientific literacy within Tongan science classrooms and how teachers can navigate the tension between encouraging critical thinking and cultural behaviours that avoid questioning. Their findings suggest that teachers may consider their style of delivery to encourage open questioning when, upon reflection, they use closed questions that do not. However, they do note that there is an increasing shift, especially in the younger generation, to embrace questioning if it enables clarification and explanation rather than questioning the authority of the teacher.

Taking science in the Kingdom of Tonga.

The attitude and experiences of science learners in Tonga were quite different from the discourse around 'Pacific students taking science' in Aotearoa New Zealand (see Chapter Nine). However, the school they attended influenced the KOTE experiences. Although all

students must pass an exam to enter college, some schools are more well-resourced and established than others, enabling them to teach a broader curriculum and be perceived by some as 'better' schools. As a subject, science is compulsory in Forms 1 to 5 (Years 7 to 11 in Aotearoa New Zealand); Forms 6 and 7 students can choose from biology, chemistry, and physics. In general, many of the KOTE participants' schools expected students to take science:

> *In Tonga its normal, you talk to other students, they say kuo alu o saenisi, alu ae taime, 'I am going to go to science class now'. I feel its normal for people to take science and maths, it is more normalised to do science and maths than here (Setaita, KOTE).*

Lyons' (2006) study of successful science students in Australia found their sociocultural backgrounds, including their parents' education levels and socioeconomic status, were very influential in their decision making. Those who continued in science did not necessarily have positive experiences of school science, often opting to continue because of the 'strategic value' of science for their future education or career, rather than interest or relevance. These findings are consistent with the experiences of KOTE participants. Some suggested students took science because their career plan required science, or their parents had insisted:

> *Science in Tonga? I think people take it because they had to [at my school]. But you don't have anywhere to go with science in Tonga, apart from going to the nursing school. If you don't want nursing, no-one's going to do it. The people who take science are the more ambitious people, or their parents told them to do it. A lot of them wanted to become doctors, but there is no opportunity to do that [in Tonga]. They are popular subjects because people always encourage them, you can do this, and you can do this. But, in the end, the reality is, if you have a Tongan passport and are not good academically, you have absolutely no possibility of proceeding in that area so [in general] the more popular subjects are business, history and English (Mele, KOTE).*

The limited tertiary options in Tonga mean subject selection has a different impact on career pathways than in Aotearoa New Zealand. Seven of the KOTE participants were born in Aotearoa New Zealand but raised in Tonga; their New Zealand citizenship allowed them to return to Aotearoa New Zealand, to study. Likely, knowing they were able to study overseas with a broader range of tertiary study options (and subsequent benefits) influenced their education pathway, and perhaps their self-efficacy.

Celebrating success.

The KOTE participants often spoke about public celebrations of success in Tonga, particularly those emphasising academic success. In general, taking science and education were valued differently in Tongan and Aotearoa New Zealand:

> *Science was cool in Tonga… only the cool kids do science, whereas here, only the nerds do sciences …Being smart in Tonga is a good thing, more than here. Kids here are more about sports... the cool guys here play sports whereas in Tonga, the cool guys are good in school. …Maybe they value high school more in Tonga, the whole country, as a culture, as people, they appreciate high school more? You see our school graduations on TV, whereas here… you never hear about a dux of a school being announced on 3 News or anything. Whereas in Tonga, high school grad would take three hours and it would be live on TV. Maybe that says something about society (Naua, KOTE).*

Emphasising success created a different environment for valuing academic achievement and doing well, linking back to Tongan ideas of *poto* and the purpose of *ako* (education) to improve an individual's ability for the good of all (Māhina, 2008). Being educated is beneficial because of the acquired knowledge and understanding that comes from education but also the possibility of social migration; in a highly stratified society such as Tonga, this is important. The benefit to society is valued, particularly in a culture that favours community over individuality (Kalavite, 2010). Publicly recognising academic success continually reinforces the importance and purpose of *ako* and the value of being *poto* to wider society (see Chapters One, Four and Five for more detail). In some parts of the secondary education system, academic achievement garnered certain privileges and respect:

> *[If] you get above a certain percentage in the internal school exam, you get your name written on a board, and everyone worships you and praises you for the rest of your life. If your name is on that board, you get privileges that other students don't, [there is] prestige that comes with it (Mele, KOTE).*

Teachers heavily influence student self-efficacy. When teachers celebrated success by giving positive feedback, it often improved self-efficacy: "*my teachers [in Tonga] were always praising me and saying, you are good at science, you are good at this… I started to think about myself, that I have these qualities*" *(Mele, KOTE).* In contrast, her teachers at a high decile school in Aotearoa New Zealand often ignored her in class, and she started to fail. Other participants, particularly those who moved to Aotearoa New Zealand for intermediate

or the beginning of secondary school, felt they would have done better if they had stayed in Tonga:

> *If I had stayed in Tonga, I would've done better, taken things more seriously… because in Tonga, they are really into doing well. When I was there, we used to compete, that made us want to do well. When I came to New Zealand, I didn't have that, so I didn't push myself. I think I would've done a lot better, because I had always done well. It was expected [of me], and when I didn't do well, I was embarrassed, I was like 'Oh my god, I didn't do well!' …If I had stayed, I would've done well. I would've done better than what I did when I was here (Malia, KOTE).*

These stories add to the debate about when, or if, migration to Aotearoa New Zealand for education should happen, as discussed above.

Language of instruction.

Learning science in English can negatively impact non-native speakers' achievement because of the complexity of the scientific terminology used and the essential abstract thinking, both of which require high language proficiency. Several studies have compared the outcomes for students learning science in English or their first language in contexts where English is not a native language (for example, Yip & Tsang, 2007). The findings highlight the difficulty of conceptualising and learning science in English; students taught in English were more likely to form misconceptions than those taught in their native language. Similar difficulties were described in this research. For example, the issue of learning content in Tongan and having exams in English: "*at my school, we would have the exams in English, but we would be taught in Tongan. Even English was taught in Tongan [laugh], so you can imagine what my struggle was" (Alau'ua, KOTE).*

The language of instruction varied depending on the school; most schools in Tonga teach in Tongan, some in English. The official language policy for secondary school used to require the use of English in all subjects except Tongan. The Tongan language maintenance policy launched in 2009 increased the emphasis on using Tongan language but with an expectation of 50/50 split between Tongan and English language in secondary education (Vea, 2010). This situation meant the KOTE participants had different perspectives on the use of English or Tongan. For some, learning science from a fluent Tongan speaker made it easier to understand, especially when they used analogies that were relevant to the student audience:

> *The [teachers in Tonga] were the ones that helped us understand what science was all about and talking about the English science terms and trying to make it into our terms… they have the same explanation that they have here [in Aotearoa New Zealand], but sometimes you can't understand it when it's all English. I think the way they explain it in Tonga, in Tongan, made us understand more. I remember our bio teacher talking about the organs and the cells, and they explained it in Tongan, in Tonga we have different levels [of hierarchy], there is a king, and it goes down, and the [teacher] explained it thinking of organs in the body and the [biological] levels …It was helpful for me and other students, because we didn't think of it as that simple. When they make analogies here [in English], it takes time [to understand] (Vaea, KOTE).*

Chigeza's (2008) work with Indigenous Australian students explored a similar issue, that "students learning school science navigate language negotiations before negotiating the language challenges in science learning" (p. 91). This work is an example of the effectiveness of integrating IK, systems, and culture into the science learning process to explain complex concepts in an appropriate and relevant way.

Interestingly, the participants who learnt in English felt they benefited as they had strong academic English skills, especially when they moved to Aotearoa New Zealand:

> *…For me, one of the best things growing up in Tonga… your written English will always be better than your spoken, whereas here it's the opposite, written English is always under par because you learn to write first before you speak… You are already trying to speak Tongan here and it's hard anyway. But then you have kids that try to learn English at school here and learn Tongan at home, and they end up not being fluent in either, and that could end up being the negative effect (Naua, KOTE).*

Learning science often involves learning a new language, mainly to communicate ideas and concepts effectively. Nevertheless, "high linguistic competence" does not guarantee communication; it also requires familiarity with equipment, activities, and expectations (Rollnick, 2000, p. 97). Therefore, like the participant above,

> second language learners in a formal schooling situation are doubly challenged, in their need to learn both the social practice of the language and its place in the new social practice they are attempting to join, in this case, science (Rollnick, 2000, p. 98).

Style of delivery.

The global reform of science education over the last few decades has favoured inquiry-based instruction over traditional didactic instructional strategies. Didactic teaching is generally assumed to be highly prescriptive and to encourage surface learning, whereas inquiry-based science instruction is seen to promote understanding and be more effective for achievement in science (Gao, 2014). Nonetheless, a recent comparison of international data indicates that both methods have variable effects depending on the country and level of student performance; neither method is consistently associated with achievement (Gao, 2014). Roehrig & Garrow (2007) indicate no significant difference between the two methods and student achievement outcomes, while Blanchard et al. (2010) found students were better off with didactic instruction than inquiry-based instruction if "the interaction with the teacher was not properly structured" (p. 607). They suggest "teas[ing] out elements of teacher actions that are more important in shaping student achievement during inquiry[-based instruction]… [as] teaching is always an act of the teacher translating a curriculum… there is no such thing as a "teacher-proof" curriculum" (Blanchard et al., 2010, p. 610). Alternatively, Dean and Kuhn (2007) suggest that using both didactic and inquiry-based instruction produces a strong student performance and engagement in assessment over time. This research implies variability and contention regarding which instruction method or combination works best in different learning contexts. Thus, the narratives that follow provide essential insight into successful Tongan science learners' perspectives.

Most KOTE participants described experiencing traditional didactic methods of content delivery in Tonga, which they generally liked:

> *We usually did theory-based lessons, no hands-on stuff, she would stand at the front and use chalkboards… [we would] take notes, a lot of taking notes. She would draw a lot of diagrams and we would draw it ourselves, maybe hand out tests and exercises, to prepare for the test…my teacher was one of the best ones. That's why I liked biology, because my teacher was good (Inoke, KOTE).*

Faamanatu-Afele (2016) indicated that Pasifika science students like clear learning objectives and explicit (i.e., didactic) teacher explanations. The Tongan science learners in this research agreed; they also appreciated any noticeable use of structure in their lessons:

> *…they used different methods, [the teacher] would use a projector …and he had a*

very structured way to do things… he would outline learning outcomes and then talk about what he needed to talk about. At the end he would give you some interest-only things, and then when he gave you the test you weren't surprised what was on it. For his test I was basically one mark off every single time. He also gave you bonus questions at the end, which were fun. The other teacher that I liked, she drew on the blackboard, she summarised stuff, she had a textbook, she would write at the blackboard, drawing stuff, then she would fill up the board, go back to the first bit and wipe it off, so you had to keep up (Mele, KOTE).

According to Lee, Buxton, Lewis and LeRoy (2006), "researchers and research programs have differing views of the manner in which students' language and culture intersect with school science and what the implications are for instructional approaches" (p. 609). Their research findings indicate variability in how students of different cultural backgrounds respond to different teaching practices in different places. Besides, Woods-McConney, Wosnitza, and Sturrock (2016) question whether inquiry-based science has had any substantial effect on student achievement. The above narratives suggest that didactic instruction is still an effective tool in the Tongan science context and supports Gao's (2014) argument that different contexts will respond to instruction methods in varying ways, thus questioning any shift to inquiry-based pedagogy only.

Inquiry-centred instruction emphasises cooperative group learning as it imitates how scientists work as they question, collaborate, challenge, and critique (Woods-McCooney et al., 2016). Group work has also been identified as an effective strategy for teaching science in Aotearoa New Zealand secondary schools as the discussions and working together builds self-confidence and enhances learning and deep thinking (Faamanatu-Afele, 2016). Nevertheless, according to the KOTE participants, group work was not often employed in Tonga:

SF: Did you do much group work in Tonga?

Vaea: I think it's more the whole class doing it sometimes, not really groups in Tonga.

The absence of small group work makes sense in this context if the Tongan teaching practice favours didactic learning methods; however, it would be interesting to consider why group work is thought to be effective for Pasifika learners in Aotearoa New Zealand but not widespread within the Tongan education system.

Approaches to learning.

Several participants talked about the emphasis on memorising and rote-learning in Tonga. Despite the overwhelmingly negative view on rote memorisation as a surface-learning tool, some participants felt memorising had a place in their learning:

> *In the Islands, it's learn that, memorise all of that [laugh] …the way they taught science in Tonga, instead of trying to understand it, they want us to know it, so all we did was memorising and stuff… I did pretty alright in Tonga (Fatai, KOTE).*

This story suggests that rote-learning can be a useful tool for some aspects of learning and achievement in science; although they were memorising, this participant was still doing "*pretty alright*". This response may relate to the types of assessment used in Tonga, as memorising can be effective if the assessment tools are wanting information to be regurgitated. Yet, it is also essential to argue that memorisation is required to learn most forms of knowledge and does assist the understanding of science concepts, and that rote learning and repetition are essential for the learning of science theory (Johnson, Chuter & Rooney, 2013).

Another participant felt that rote learning allowed them to do well, and if they had stayed in Tonga, they might have done better:

> *[In Tonga] they cram heaps into you, heaps of rote learning, you don't understand it, but if you can regurgitate it, you can do well. I don't think it's the best way to teach but… if I had stayed in Tonga, because they do that all the way up to high school, I think I would've done better, [and] taken things more seriously than here (Malia, KOTE).*

It is interesting to consider whether this participant's comment that they would have done better if they had stayed in Tonga relates to the continued use of rote learning, or because they were more comfortable and familiar with the Tongan system and that would have made them take their achievement more seriously.

The shift to the Aotearoa New Zealand education system often resulted in a new emphasis on comprehension, which the participants felt created deeper, longer-term understanding:

> *I think memorising is my strongest point, but when I moved to New Zealand, I found it hard to understand it, plus the language barrier was a big thing… the*

> *good thing about how New Zealand is teaching [science] is, after the course you still know stuff. In Tonga you memorise stuff and then you forget all of it… [its good] for tests, for short-term, but in terms of long-term, you remember stuff but not the whole thing (Fatai, KOTE).*

This story suggests that memorisation in science is a useful tool either because they see it as valid, they lack other learning techniques, or what they are learning has limited relevance. Building on prior knowledge makes learning new knowledge more meaningful, demonstrates it is relevant to what they already know, and the learner must relate the new knowledge to their previous knowledge; if they are unable to meet these requirements, then the learner will use rote learning to memorise their new knowledge (Grove & Bretz, 2012).

Availability of educational resources and content delivery.

Resources are an essential aspect of science learning, particularly for the practical component (for example, Okebukola & Adeniyi, 1987). Nonetheless, the participants had few opportunities for practical work:

> *In Tonga, we did [practical work], but there was a lack of resources. We did microscopy once, but the microscopes weren't working well, so probably once or twice we did a practical. The two times I remember, they were for the exam that we did because it was required that we do a practical exam, but throughout the year, not really (Katinia KOTE).*

An alternative was for teachers to deliver the practical component:

> *One of the disadvantages of Tonga… You are good at theory, but then you can't do the actual work which sucks. …[its] from the textbook, they read it to you, or they give it to you to read. You are lucky if you get one experiment a year, and the teacher will do it, and you watch. I thought it was fun in Tonga reading about it until I got [to Aotearoa New Zealand], and I got to do it (Naua, KOTE).*

Although many stories mentioned the lack of science resources, one participant praised their textbook:

> *…there were definitely some [things] that I knew that helped me when I came here… I enjoyed chemistry in Tonga, we had these textbooks that helped me in Tonga. Because of that good foundation… that's why I liked chemistry. Here, I didn't do that well in terms of grades, [but] in Tonga, they had good textbooks, which is a surprise because you wouldn't think Tonga would have any good textbooks… (Setaita, KOTE).*

This story also supports the possibility that minority students do benefit from more traditional methods of teaching science. It also provides a perspective to counter the emphasis on engaging minority ethnicity students in active inquiry for them to understand the content and be successful (see Thadani, Cook, Griffis, Wise & Blakey, 2010).

In the early 1990s, Futa Helu, founder of the 'Atenisi High School and University in Tonga, suggested that limited access to practical science teaching during their schooling meant Tongans had a poor understanding of science. He felt understanding came from being able to "perform, observe, design, experiment. Without lab experience, science is just poetry" (cited in Coxon, 1992, p. 91). According to the participants, the limited access continues to be a concern, particularly for chemistry which was hard to understand without practical activities:

> *…not having all the resources that we needed… in terms of teachers and what we needed for science. Back in our high school we didn't have a proper chemistry lab, so we never got to do most of the experiments that we were meant to do. It was just drawing pictures and assuming that was what would have happened if we had had the right equipment [laugh] …for biology and chemistry we had a shortage of equipment (Alau'ua, KOTE).*

Some suggested that the lack of resources affected their teachers' ability to teach:

> *In Tonga, it was more the lack of resources. The teacher was passionate and wanted to teach us, but sometimes he lacked knowledge. He didn't have enough resources, so if he was trying to teach us something in chemistry, we didn't have resources to see it happen, that made it less engaging (Katinia KOTE).*

There are strong correlations between science achievement and the frequency of access to laboratory resources, more so than resource quality; however, the quality of resources is more strongly correlated with student attitude (Okebukola & Adeniyi, 1987). Therefore, even schools with limited resources can drive student achievement if the teaching plan incorporates frequent practical applications. In Tonga this was often achieved with frequent fieldtrips:

> *We had a lot of trips out into the coral reefs, that was pretty good… mainly to the beach, to the coral reef. That's what made me enjoy biology more, and in chemistry, because we rarely had any lab sessions, we didn't have any equipment to use, so we would do it sparingly (Inoke, KOTE).*

Using local environments to teach science demonstrates relevance to students and a focus on inquiry-based science instruction (Thadani et al., 2010) as students were encouraged to explore their surroundings rather than read a textbook or do an in-class activity.

Teacher-student interaction.

Most KOTE participants described their teachers in Tonga as helpful and supportive:

> *What made me successful in science in Tonga was the teachers. Even though [they] probably got their degrees from Tonga… the time they spend with students… they give it all, to get it into the kids. I remember my chemistry and biology teachers, because they knew they were some of the hardest papers, they would be there to help, and they knew what we were going through… what made me successful in my science was them helping… (Vaea, KOTE)*

This story highlights the influence of a positive teacher-student relationship on success and achievement; despite appearing to consider their teachers' qualification of lower value, this participant felt the dedication to their students more than made up for it.

Some Tongan schools had small senior secondary science class sizes allowing some KOTE participants to spend more time with their teacher, which they felt supported their learning:

> *In Tonga, because there wasn't a lot of students in our school or our class, it was more intimate, it was more personal, we engaged a lot. But here, there were a lot more students… [In] Tonga, they could meet your needs a bit more than here because there were a lot of other people to teach (Katinia KOTE).*

Small class sizes influence student-teacher interactions, enabling teachers to know their students better, have more time to teach, and individualise pedagogy (Harfitt, 2013). They also improve achievement, particularly for ethnic minorities (Wilson, 2002). While not an ethnic minority in Tonga, the KOTE participants were when they moved to Aotearoa New Zealand. As a result, this research provides insight into how the teacher-student relationship, which is extremely important for Tongans (and Pasifika students), is enacted in the two countries and how different factors influence success. For example, teachers in Tonga were often perceived to be easier to relate to than teachers in Aotearoa New Zealand:

> *It was definitely a communication barrier because I couldn't understand [the accent], but also, I couldn't relate to him. In Tonga it was easy, oh sweet he's a Tongan teacher I can get it, it's hard to explain, yeah… there was a bit of not*

relating to the teacher here, so I didn't feel as comfortable to ask question and stuff (Setaita, KOTE).

Some KOTE participants criticised the expertise of the teaching staff in Tonga, occasionally suggesting their teacher had not known the content they were delivering very well, which impacted on the participant's learning:

In Tonga, the teacher wasn't as knowledgeable as I think he should have been, so not having answers to questions, and reading content and not being able to understand and [the teacher] not being able to explain it, that made it hard to learn (Katinia KOTE).

Yet, despite their supposed inadequacies, Katinia felt her teachers in Tonga tried to help their students more than their teachers in Aotearoa New Zealand did:

In Tonga I could tell my science teachers, they wanted to help, but they lacked knowledge a bit so if you asked questions sometimes they couldn't answer or explain because they didn't know… but here my teacher was knowledgeable, she was young, she was good, [but] she didn't know how to deliver the message, she assumed we knew a lot already so she rushed through things a lot (Katinia KOTE).

Other stories described how teachers in Tonga interacted with their students, for example, motivational sessions which in turn stimulated attendance:

[My teacher] would always have these sessions where she would give pep talks to us about our future …As a class, she was always trying to motivate us, she was good at motivating us and making sure that we always came to class. Because in school, if we didn't, she would either have detention or something similar, she would always motivate us to study, and when she teaches us you can tell she is interested in her subject… her being interested… made us interested as well, that's why her classes were often full (Inoke, KOTE).

By no means are the KOTE participants implying Tonga is perfect, but this teacher's approach reinforces the importance of building secure connections that encourage student achievement and success and indicates an interest in the students. It also demonstrates a perspective that values the collective; in Tongan culture, education should be for the 'benefit of the whole' (Vaioleti, 2011), in this case, the collective achievement of the class

The Tongan (education) experience

Several participants spoke about the experience of education in Tonga, perceptions of the quality of Tongan education, and referred to a 'Tongan Experience', usually meaning time

spent in Tonga for education and acculturation. Their narratives related to what they felt education in Tonga was like for many students, including references to work ethic and study opportunities outside of Tonga.

The Myth of the Tongan Education Experience.

Enough participants referred to Tongan education in such a way during the interviews for this research that the phrase the 'Myth of the Tongan Education Experience' was developed to acknowledge outsider perceptions of education in Tonga, including Aotearoa New Zealand-based teachers, students, and family. Some KOTE participants had family in Aotearoa New Zealand who questioned the quality and validity of the education they were getting in Tonga:

> *I predicted it would be a big transition for me to come straight after high school to uni here, so I planned to finish Form 6 [Year 12] and come and do Form 7 [Year 13] here, to get a feel of how the education system is. But I also wanted to stay and be with my friends. I ended up staying in Tonga… an aunty who lives in New Zealand suggested I come and repeat Form 7 here to be better prepared for uni, but when I applied after high school, I got accepted to uni first-year (Alau'ua, KOTE).*

Schoone (2008) suggested that second-generation Aotearoa New Zealand-born Tongans have been strongly influenced by deficit narratives that counter those of their parents. However, this research has moved the focus away from the nationality of the participant to whether they were educated in Tonga or Aotearoa New Zealand; it seems that some Tongans who have resided in Aotearoa New Zealand, whether Aotearoa New Zealand-born or not, are strongly influenced by predominantly deficit narratives regarding education in Tonga. Fortunately, this research provides numerous examples of how their education in Tonga has contributed to their engagement, enjoyment, and success in science, thus providing evidence to counter deficit perspectives. For example, although Alau'ua completed her entire secondary schooling in Tonga, she has recently graduated with a medical degree.

Despite the KOTE participants frequently describing their science content as more advanced or harder than the content when they moved to Aotearoa New Zealand, their Aotearoa New Zealand teachers often made them feel singled out:

> *I remember when I first came here, they made me sit in the front row to make sure I learnt everything… sometimes they would talk slower to me, so I would get it. It was borderline racist because I probably knew what they were teaching more*

> *than [the other students] …when I came here, what we were doing was a step-down from what we were doing in Tonga …which is weird because… I thought coming here everything here would be harder, ten times harder (Naua, KOTE).*

Naua also described how his Aotearoa New Zealand teachers gave him extra work to do to 'catch up', even though he had already learnt it in Tonga. Perhaps this story best demonstrates the perception of the type and quality of education available in Tonga:

> *At high school here …I had to do my own work; I was separated from the class. I [was] given special homework… because I had to 'catch up' …it went on for a whole term, and I thought 'What's going on here'? I have been doing good in my tests (Naua, KOTE).*

As mentioned previously, some considered the formal education system introduced by the missionaries in the 1800s was too advanced for Tongans (Coxon, 1988; Hinango, 1987). Nevertheless, the reflections of the KOTE participants, most educated in Tonga within the last ten years, suggest their Tongan education was more pertinent to their university study than the equivalent schools provided in the Aotearoa New Zealand system.

Multiple KOTE participants suggested that staying in Tonga would have been better for their educational success although one participant saw benefits in moving to Aotearoa New Zealand for the final year of secondary school to acclimatise to the Aotearoa New Zealand system, rather than shifting to achieve educational benefit: *"I would say finish high school in Tonga; if I [could go] back, I would finish high school in Tonga, or maybe come here in Year 13 to get into the system, to learn the Kiwi culture" (Naua, KOTE).* This idea is explored further below (refer to 'Taking science in the Kingdom of Tonga').

The phrase 'Tongan experience' was also used to describe youth going to Tonga to experience the education system and be exposed to Tongan culture, language, and values. Schoone (2008) has previously described 'The Practice' of sending 'at-risk' youth from Aotearoa New Zealand to Tonga to help socialise them into Tongan life, to *fetokoni'aki* (helping one another, cooperating), address issues of discipline and for education. In this research, the 'Tongan experience' seems to have no set time frame but mostly occurs during the later years of secondary school,

> *There were talks about me going to go back to Tonga, to complete the standard one year for the Tongan experience but that never happened… My dad wanted*

> *me to go and learn the language, experience life as a Tongan. My mum didn't want to jeopardise my schooling, and she didn't want me to have to go and then come back and repeat a year… (Grace, KOTE).*

This story demonstrates the conflicting perspectives that can exist regarding the use of The Practice and education in Tonga, even within one family. Where the father was encouraging, the mother was not; the deficit thinking regarding education in Tonga is evident in her suggestion that spending time in Tonga would necessitate repeating a year.

Tonga has a long history of migration for education, both internal migration from outer islands to the main island of Tongatapu and from Tonga to countries such as Aotearoa New Zealand and Australia. As per Schoone's (2008) research, one KOTE participant who was sent to Tonga as a teenager was sent for a range of reasons, including cultural, religious, disciplinary, and educational:

> *I went because I didn't know how to speak Tongan. I knew English and I knew [Pāpālangi] values, so they sent me back to learn Tongan values, to learn how to pray and value my religion properly. They wanted me to know how to speak Tongan and communicate with others… It was good, it helped a lot, knowing where I come from, because I was naughty, [I] moved me to Tonga to learn discipline… I was sort of scared to go to Tonga, I didn't know what was going to be there, it turned out well… it made me appreciate living in Tonga as well (Inoke, KOTE).*

This narrative aligns with other KOTE participants who felt that their self-efficacy resulted from their experiences in Tonga; for most, their appreciation of Tonga had motivated them in ways to achieve, engage and be successful that they felt Tongans educated only in Aotearoa New Zealand were not:

> *[I] compare where I am with them [in Tonga], and at some points this [degree] is too intense for me to handle, but then I think about things like coming from Tonga, that's a main [motivator], because so many people in Tonga would love to have the opportunity… (Mata, KOTE)*

As was the case when formal western education was first introduced to Tonga, some members of society have easier access to education. However, the KOTE narratives relate this more to access to higher education opportunities: "*basically in Tonga, there isn't that many tertiary study options… if you are planning to do uni, it's a [scholarship overseas*]*" (Alau'ua, KOTE)*. More than half of the KOTE participants were born in Aotearoa New Zealand but

raised in Tonga. Qualifying for a New Zealand passport meant they had the right to return to Aotearoa New Zealand, to study. This has likely wielded some influence over their education pathway, and perhaps their self-efficacy, as they would have understood the possibility of studying overseas, allowed them a broader range of options for tertiary study and the subsequent benefits this education would bring.

Citizenship also appears to have influenced the length of residence in Tonga: almost all KOTE participants with New Zealand passports completed at least one year of their senior secondary schooling in Tonga; the Tongan-born migrated to Aotearoa New Zealand at a much younger age on average. Perhaps this is the result of sampling bias and other factors, including their place in the family (i.e., eldest or youngest child) rather than just citizenship[42]. Regardless, it raises an interesting dilemma regarding when to migrate to Aotearoa New Zealand for education, if at all; many participants' narratives seem to suggest that staying in Tonga for as long as possible, or at least having a portion of time spent in Tongan schooling is beneficial for student learner identity and success in university science pathways. It is also essential to remember that all the KOTE participants had at least one parent with a tertiary qualification, highlighting the importance of parental education and the subsequent cultural capital it can bestow on their children.

ANZE participants' perspectives on education in the Kingdom of Tonga.

Most ANZE participants had little to no personal experience of education in Tonga. A few had spent short periods of time in Tonga; one or two had spent time in Tongan schools and were able to make comparisons with their experiences in Aotearoa New Zealand. Despite not experiencing the Tongan education system directly, some had opinions based on the 'Myth of the Tongan Education Experience' from friends or family, or from their interactions with people who had been educated in Tonga and migrated to Aotearoa New Zealand. The most common perception was that the Tongan education system had provided a better learning experience and preparation:

[Students from Tonga] do so well… I remember when [they] came out, and I

[42] Even though a higher proportion of KOTE Tongan-born participants were succeeding in the more competitive university science programmes such as medicine, on closer examination this was often their second attempt at university study because pastoral issues (i.e., transitioning issues, home sickness, loss of grandparents, etc.) had affected their first. This may suggest that they have a different work ethic than those who had always had access to the Aotearoa New Zealand system.

> *thought 'Oh, they are probably so smart', because Tongan students are always so smart and do so well… I always wish I went to Tonga to school… My dad wanted me to go back to Tonga, to be more involved in my Tongan side because he knew that I didn't like school over here. I wish I [had], my cousins, they do well at school, and they are disciplined, I wish I went (Sina, ANZE).*

As outlined above, Tongan youth are sent back to Tonga for culturally motivated reasons, such as language and learning cultural traditions and to change their behaviour and understand who they were (Schoone, 2008). Some stories in this research also emphasise education, or a better education experience.

Contrastingly, two ANZE participants felt that being educated in Tonga is detrimental to success in Aotearoa New Zealand:

> *[My success] is because… my family is not as 'Tonganised' as my other extended family. In that sense they understand the western way of education… my other extended family, none of them have gone to university, and it's like they are in a cycle, they didn't like high school, any subjects, they aren't going to go to uni, they just came from Tonga so… the language is a barrier (Vaka, ANZE).*

This narrative indicates a very deficit perspective of education; it suggests their success results from being westernised or less Tongan, dismissing the possibility that their success could be attributed to being Tongan. Unfortunately, this perspective echoes the views of most of the Aotearoa New Zealand teaching staff the participants encountered in their secondary schooling, as discussed elsewhere. Interestingly, these two participants stated that they had never experienced racism themselves; one had witnessed their teachers treating other Pasifika students differently, just not them. Although this may be the case, it is also possible these participants have been acculturated into the western narratives, evident in the confidence with which they describe their experiences in the formal education system, in such a way that they are disconnected from the Tongan cultural narrative as Schoone (2008) suggested may happen.

Implications for Science Teaching

As explained in Chapter Two, this research was always intended to be 'socially transformative educational research' (Burnett, 2012) and align with the RPEIPP initiative. My engagement in the process of critical reflexive practice (Cunliffe, 2004) enabled me to implement a retroductive process of considering and reframing my teaching practice for my

Pasifika (and other Indigenous) students while collecting and analysing my doctoral data. A key driver for this reflexive practice was the exposure to participant stories about their experiences of science education in Tonga. As a result, I have gained a far greater understanding of the formal learning environment, how and where cultural values and knowledge are employed, and how the participants' responded to both areas. I was also able to learn more about how science education is delivered and facilitated and both the strengths of and limitations on science education in Tonga.

From these stories, I was able to consider which aspects would resonate with my teaching and learning environments. I also thought about how I could change my formal learning spaces to encourage the engagement, enjoyment, and success of my Tongan (and other Pacific) science learners, especially those educated in Tonga (or other island nations in the Pacific). I have never been educated or taught in any of the Pacific island nations outside of Aotearoa New Zealand; without the willingness of my KOTE participants to share their stories, I would not have had this incredibly valuable insiders' perspective with which to critically self-reflect and change my practice as outlined below.

Engaging Oceanic ways.

I began teaching the reproductive and endocrine systems almost ten years ago during my time in foundation teaching only Māori and Pacific students. I was always careful to acknowledge such content is *tapu* (sacred) for some students and can be affronting for cultural, religious, or family reasons. For example, I would begin class by verbally acknowledging that some students in the lecture room may feel uncomfortable because of the mixed-gender of the formal learning context, the use of anatomical images, and because it may trigger memories of an aspect of their personal history. The intention was to create a respectful learning environment, outlining expectations of respect for others, and demonstrating that I am aware that the topic is potentially a difficult one. I used this approach before beginning my doctoral work, believing that I was demonstrating my cultural responsiveness and awareness, particularly of some Pasifika cultures. When my female participants mentioned learning about reproduction during their interviews, I initially felt quite proud of my approach, believing that it was good and appropriate. Nonetheless, I subsequently realised through further analysis of my female participants' interview data, that although well intentioned, the brief acknowledgement I provided in class was not enough.

When I critically reflected on this feedback, I realised that I was not explicit enough in either my recognition of values or attempts to embed the practice of *tauhi vā* in my learning spaces. In response, I realised that structural changes would be more explicit evidence of my attempts to address this *tapu* topic. For the last five years, I have offered gender-streamed tutorial classes that students can attend by self-identified gender. This streaming allows students to choose whom they are more comfortable discussing the content in front of, female-only, male-only, or mixed gender. The response has been overwhelmingly positive, with only a few students (predominantly males) questioning why we do this. I reason that the other times they learn this content, they are not expected to participate in small group discussions for assessment (i.e., formative tests occur during the tutorial class time). This approach also empowers gender-fluid or trans-gender students to select where they feel most comfortable.

I note here that some teachers might find gender separation, in this instance, problematic. Yet I regard this as culturally responsive, with the understanding that pedagogical responsiveness can be far more nuanced than some educators may appreciate (Samu, 2015). An anonymous online survey of the current cohort indicated that having the opportunity to choose their tutorial cohort for this topic was helpful, culturally sensitive, valuable, and, for most students, considerate. This example demonstrates how understanding what students are experiencing and thinking helps educators to adjust their delivery in culturally relevant and responsive ways. In this case, understanding how much a male presence impacted on their learning made me change my course. I wanted to demonstrate that it is possible to be responsive, and that I respect values such as *anga lelei* in my course. One vision of the NZC (2007) is to reflect "New Zealand's cultural diversity and values the histories and traditions of all of its people" (Ministry of Education, 2007, p. 8), so students learn about and express their values. This statement suggests that Tongan students should be able to see their cultural values reflected in the curriculum content and that institutions and teachers should '"use knowledge and ways of relating and teaching that acknowledge the culture of being Tongan for students in the New Zealand classroom" (Vaioleti, 2011, p. 30).

I believe this example demonstrates how simple changes can create teaching and learning contexts where Tongan (and other Pacific) science learners can safely express their

language, culture, and values so that they can engage, enjoy and succeed. They also demonstrate how *fanongo*, listening to the silences, can help educators understand what is unsaid. Without acknowledging my students who did not engage when learning about reproduction, I would never have truly understood why. It would have been more convenient and easier for me to assume that they were quiet, shy Pasifika students, rather than discover that there was a complicated situation that they were trying to manage in the most culturally appropriate way amongst themselves.

Concluding comments

In this chapter, the KOTE participants have described the formal learning environment and how Tongan values, customs, culture, and knowledge influenced their experiences of the formal education system. They shared many stories of science teaching, including what it was like to take science and science delivery in Tonga. The participants also spoke about the perceptions of education in Tonga termed here the 'The Tongan (education) experience' and the associated myths and beliefs held by outsiders, both Tongan and non-Tongan. This chapter has provided means to counter the deficit narrative of education in the Pacific by recognising the history of education in the Pacific, both Indigenous and western. All these insights provide suggestions as to how we may improve science education in Aotearoa to improve engagement, enjoyment, and success for Tongan and other Pasifika science learners. Some of these suggestions have already driven change in my teaching and learning approaches; the examples described here demonstrate how I valued and portrayed this valuing explicitly to my students and in my teaching. The following chapter will elaborate on the participants' experiences of science education in Aotearoa New Zealand.

Chapter Seven – Education in Aotearoa New Zealand: Secondary school science

This chapter presents the participants' stories in two sections, beginning with teacher-student interactions and relationships, their considerations of 'good' teaching, and the delivery of their science courses. The second section covers participant narratives about the advice they received regarding science as a career, the benefits of celebrating academic success, and their thoughts on NCEA. These stories provide a unique insight into the impacts of school culture and the learning environment on the experiences of Tongan science learners in Aotearoa New Zealand.

Secondary school science education

The primary purpose for Aotearoa New Zealand secondary school science is preparation for university-level science study and science-related careers, and to a lesser degree, increasing scientific literacy (Coll et al., 2010). Thus, progression through senior secondary school science entails shifting from generalised science (combining essential background in differences sciences with the foundations for later specialisation) to learning knowledge (content, facts, and principles) within specific disciplines, i.e., Physics, Chemistry (Bull et al., 2010). While the NZC (2007) emphasises science through 'Nature of Science', "an organised process for obtaining new knowledge – not simply a collection of facts" (Gluckman, 2013, p. 3), teaching and the senior-level assessment structure means "[s]econdary school science programmes largely continue to teach conceptual knowledge in discrete disciplines" (Bull et al., 2010, p. 10). As discrete disciplines with specific conceptual content, methods, and theoretical understandings, teachers must have a good grasp of subject knowledge to ensure student engagement (Williams, Eames, Hume & Lockley, 2012). Nevertheless, teachers in Aotearoa New Zealand often teach content across different disciplines and outside of the scope of their qualifications (Haigh & Anthony, 2012). This chapter presents the participants' reflections about their secondary science experiences. A particular focus is on how the participants have navigated social interactions and relationships with their

educators, peers and how school culture has influenced their teaching and learning experiences.

Social Interactions– Navigating relationships and school culture

Each school's culture creates a different learning environment that influences how teaching and learning occur. Schools, as institutions, have their culture, defined in this research as the "norms, structures, rituals and traditions, common values and actions" as well as the guiding policies and 'in-house rules' that make up the unique culture of individual schools (Prosser, 1999, p. 8). External factors also influence school cultures such as the surrounding community, government policies on education, and the economic climate. Thus, within a school the staff may or may not be aware of how their decisions about such things as pedagogy selection are influenced by the school culture or how much it determines "what teachers pay attention to, how they identify with their school, their work ethic, and the success they achieve in relation to their goals" (Meier, 2012, p. 806).

Teacher-student interactions & relationships.

The teacher-student relationship is critical in any educational setting, as "apart from family background, it is good teachers who make the greatest difference to student outcomes from schooling" (Hayes, Mills, Christie & Lingard, 2006, p.1). Therefore, I have considered two pedagogies that focus on how teachers relate to students, culturally relevant teaching, and culturally sustaining pedagogy. The concept of culturally relevant teaching, which emphasises the influence of classroom interactions on academic success and the importance of bridging the gap between the cultures of home and school. Drawing on Ladson-Billings (1995), culturally relevant teaching encompasses the belief that all students are capable of academic success, and that teachers should be pedagogically responsive and be part of the community. It also emphasises equitable and reciprocal student-teacher relationships, connectedness with all learners and teachers demonstrating passion, and facilitating learning. More recently, Paris (2012) has introduced the concept of culturally sustaining pedagogy which values "our multiethnic and multilingual present and future" by emphasising the need to "support young people in sustaining the cultural and linguistic competence of their communities while simultaneously offering access to dominant cultural competence" (p. 95). The goal is to go beyond making content and teaching practices

relevant. Instead, it urges that we find ways to foster and support multilingualism and multiculturalism "as part of the democratic project of schooling" (p. 95).

The social relationship aspects of both culturally responsive and culturally sustaining pedagogical frameworks have informed the analysis and organisation of the participants' narratives regarding their interactions and relationships with their teachers. The stories have been discussed together to showcase the similarities; they are separated into KOTE and ANZE to demonstrate points of difference. The negative stories reflect the issues in the teacher-student relationships for their Pasifika science learners, particularly the influence of deficit thinking on behaviour and interaction; the positive stories highlight what works when relationships and interactions are non-deficit and based on respect rather than judgement.

'Good' teachers.

Understanding what 'good teacher' means is useful as "ideas about good teaching are embedded in the design of educational institutions, and lurk in our talk about curricula, educational technology and school reform" (Connell, 2009, p. 214). However, multiple factors complicate conceptualisations of 'good', including the audience and context. Cultural diversity also adds ideas about the value placed on content knowledge and teaching experience, personal qualities, including ethics, and classroom practices, such as teacher-student interactions (Reichel & Arnon, 2009).

The narratives below provide an understanding of what 'good' science teaching is for successful Tongan science learners. Most participants used the phrase 'good teachers' when defining an effective teacher. Like Hawk, Cowley, Hill and Sutherland's (2002) work with Māori and Pasifika students and Peacock's (2006) work with First Nation students in the United States, personal qualities and values were hugely influential; the qualities of a 'good' teacher were strongly associated with someone they respected, especially if they were passionate. For example,

> *[They are] interested in teaching us what they are about to teach; they are passionate about what they are teaching. They are not standing there, monotonous from beginning to end. To me, that's most important and being accessible, being willing to present their information in a way that others can understand, not 'This is how I am giving it to you. You need to find ways to understand that', that's what I feel a good teacher is. Teachers [who] are passionate about your learning, [who say] 'This is important, please focus and*

> *listen'. …teachers play the most important role in engaging the students and making me feel I can pass, and if they told me how I can pass, I can do it… ('Ana, KOTE)*

Like Peacock's work, 'good' teachers used a range of techniques to deliver content understandably and engage with individual learners to help them achieve:

> *[They have] your best interest at heart, someone that will push you to your potential, someone that's good at teaching. They always follow you up on your work and they've always got your back, showing that they care. …if you enjoy a subject it's more likely that you liked the teacher… if they are good at teaching, if you understand when they teach or when you don't understand it, they stop teaching and they try and get you to understand, and they are friendly (Naua, KOTE).*

They also treat all students the same:

> *[They] know how to interact with the students… [they use] filling in gaps or tasks or activities during the lecture, maybe in a small group, getting students to act out something. Just interacting and something fun, changing the way they teach, [not] having the same teaching technique throughout the course… treating every student the same (Mata, KOTE).*

Small acts such as learning students' names make a big difference,

> *A [good] teacher knows their students and likes to motivate them… [you should] at least say something to your students, or know their names, their actual names, engaging with the students personally (Inoke, KOTE).*

'Good' teachers also make content relevant and relatable:

> *Good teaching would be, using examples like real life, something you can imagine or do …good teaching would be showing and then making you do it… hands-on stuff (Alau'ua, KOTE).*

Making personal links with students helped with relatability:

> *During class, of course you must be professional and all, but you can… share how you [as the teacher] learnt those concepts amongst your students (Kalala, ANZE).*

Teaching styles.

The NZC (2007) guidelines create flexibility for science curriculum delivery and encourage a more learner-centred approach (Coll et al., 2010). Yet, participants in my

research usually experienced a 'content-driven, teaching approach' employing limited interactive pedagogies. Hipkins, Barker & Bolstad (2005) suggested individual teachers' theories of learning and pedagogical content knowledge, and a lack of appropriate guidance and resources informs the "mismatch between curriculum reform rhetoric in science education and actual classroom practice" in Aotearoa New Zealand (p. 243). The participants in this research agreed. For example, a common criticism was the over-emphasis on learning from textbooks and copying off the board,

> *In Year 13 I got a new teacher, he was super blasé, real kickback. He didn't teach us. He'd say, 'Today we are talking about Newton's law part 1. This is the page we are working from, so open your workbooks and do this question'. It was lazy and not interactive at all… I lost that drive, that interest. I didn't feel that I could approach him. I didn't feel I was getting anything from going to that class for an hour a day. I could do at home what I was doing there, and I would still not understand it either way. I didn't see the point in putting in extra effort. I knew that I wouldn't get it, there wasn't help there available to me (Lashandra, ANZE).*

Such practices have negative impacts on attitudes to science and achievement (Odom, Stoddard & LaNasa, 2007). Furthermore, teachers with low levels of personal teaching efficacy utilise limited teaching techniques and limit their preparation and planning (Deemer, 2004). For example,

> *In Year 13 biology, our teacher was one of our deans. He was always busy, and I felt he didn't do much planning, so we would watch videos. It was a lot of, 'Right, we're at page… and he would flick to the page to find out what page. '…page 52 today', and that was every day, video and workbook. He didn't do any teaching (Lashandra, ANZE).*

Group work and peer discussion increase "cognitive and metacognitive thinking skills" in science (Jones & Baker, 2005, p. 138). Accordingly, participants in this research felt that discussion helped them engage with their learning:

> *I remember sometimes I found it quite lazy of the teacher to write things up and then sit there silent while we are writing stuff down. I would have preferred more time with them explaining things, going through, maybe doing more problems in the textbooks as a class. We were left alone with the textbook and had to do the problems and they would walk around and help whoever… [why not] give us the notes typed out, give us a bit of reading time and then go through it [together]? (Jake, ANZE)*

….you want to talk about it. You get bored listening all the time so if you can talk about it, it makes the class more interesting. You can buy into it and talk about what you are learning, its more effective (Manu, ANZE).

Practical application.

Using illustrative pedagogical tools such as practical applications and models distinguishes science pedagogy from other subjects (Jones & Baker, 2005; Coll et al., 2005). It can also make science more relevant and accessible for students, often assisting with their engagement (Cowie et al., 2011). For example,

The experiments [helped me engage], I found them fun. Other than that, nothing really, that was really it, the teachers didn't help me engage (Avila, ANZE).

We had a lot of practicals. One teacher, he would do all these experiments… not doing experiments for assessments. If teachers could show us stuff then we would be more interested in what happens in real life, like 'Oh, that's so cool, I didn't realise that before' (Laulea, ANZE).

However, practical work has different capacities to aid understanding of content and the scientific process (Haigh, France & Forret, 2005). The most common approach, known as 'recipe' or highly structured practical work, can limit the experience of the scientific process, whereas 'open' investigation allows students to 'do science'. Most participants described 'recipe' laboratory practical activities; in some instances, teachers executed these practical activities while students observed. Very few participants had tried 'open' investigation:

In bio, I enjoyed the experiments. A lot of that was cool, experiments on what we were learning. Once, we had to put some bugs on an agar plate. We were given some swabs and we could go anywhere in the whole school and swab something that you thought would culture something. I thought that was fun, because we'd learnt about how to do all that stuff in that lab. Then to do it made a lot more sense and everyone tried to go to the grossest places, that was a lot of fun (Jake, ANZE).

Practical application is not always an experiment. Any form of activity that engaged with content was beneficial and enjoyable, especially if there was competition involved:

… [alternatives to] reading notes, even quizzes. Group quizzes, things like that, you find that PIs are quite competitive. They like doing team things, so group activities, a group quiz is quite good. I always enjoyed them, not saying I didn't enjoy the theory part of things, but I always loved making things more practical, [it] was a bonus and made things more enjoyable (Jake, ANZE).

Classroom communication.

Interaction and communication with teaching staff through discussing, testing, questioning, and critiquing concepts is vital in science education (Jones & Baker, 2005). Interpersonal interactions are particularly important for science teaching and learning, especially for learners who are underachieving. From the participants' stories, how teachers communicated, and the educational context they created, determined teacher-student interactions.

Asking questions & seeking help.

Asking questions is an essential part of learning as students ask questions to learn more, to satisfy their curiosity (Fitzsimmons, 2011), or clarify their understanding. For the science learners in this research, engagement was indicated by whether they asked questions, but some felt shyness influenced their teacher-student interactions and how teachers treated them. Although teachers often make decisions about 'potential' and 'realised' student achievement based on how a student communicates, they can 'misdiagnose' students with different cultural communication styles when they ignore or overlook nuances they do not understand (Gay, 2002):

> *I was shy, some [teachers] don't understand that students are different, and they take it that students are disinterested… I got that a lot… [they would] move me to the front or ask me questions, stuff like that. I knew it was just me not speaking up. Even though I would try and force myself to ask a question, you could tell that it was forced, it would be a real obvious question (Kava, ANZE).*

Teachers' understandings of social hierarchy, an integral part of Tongan culture, which influences interactions and relationships, further complicated teacher-student interactions. Relationships are maintained by Tongan values, including fatongia (duty/obligation) and *faka'apa'apa* (mutual respect). These core values are seen to be incongruent with those imposed by the dominant western education paradigm (Taufe'ulugaki, 2003), which expects students to question, especially in science. For many participants, this made it difficult to ask questions as they did not want to appear to be criticising their teacher. Many participants in this research battled with expectations to question and critique when many have been raised not to:

> *Sometimes you don't ask for help, that's my weakness. It's something I am always*

> *reluctant to do… We don't like being a burden to anyone and that's what I found difficult when I first came here, asking questions. In Tonga when we are being taught at school, if the teacher is explaining something and they ask if you understand, it's a default response to say yes, even if you don't understand it. It's very rare to ask questions when you don't understand… but here [in Aotearoa New Zealand] it was one of the things that I noticed, a lot of the students ask questions. That is something I still struggle to do. I know it would be way more helpful if I did ask questions, because often I do have lots of things that I don't understand, and I want to ask but I don't have the confidence to ask because of how I have been [raised] in Tonga… (Alau'ua KOTE).*

Teacher curriculum knowledge is an essential component of creating a safe and well-managed learning environment (Bishop & Berryman, 2009). If students feel unable to ask questions or that the teachers do not care or understand what they are teaching, this hampers their learning,

> *...[students] stop [asking] when they don't get it… a lot of my high school teachers didn't know what they were talking about. They made me feel I shouldn't bother learning it because if they didn't know it, why should I try to know it? …That's a lot of why people don't ask questions; because they don't always get a good answer. It's always the people that ask questions that do well, the people that don't, go home with their questions (Laulea, ANZE).*

The social support provided by teachers means they play a crucial role in the development of learner identity around academic achievement and educational advancement for all students. However, ethnic minority students require more social support from teachers because of their isolation in the learning environment and exposure to stereotypes about their academic ability (Syed et al., 2011).

Samu (2015) argues that teachers of Pasifika students need to understand the diversity of the Pasifika learner identity regarding teaching and learning. Rather than seeing Pasifika values and behaviours as a disadvantage in a westernised system, educators could be more aware of their importance, enabling students to balance their cultural and academic obligations. Thus, they could benefit from their Tongan culture and ensure their engagement and academic achievement (Kalavite, 2010). Recognising how these two value systems can conflict with each other also reflects culturally sustaining pedagogy (Prince, 2012), which suggests educators should be,

> interested not in relevance or responsiveness, but in sustaining and extending the

> richness of our pluralist society. Such richness includes all the languages, literacies, and cultural ways of being that our students and communities embody - both those marginalized and dominant (p. 96).

Teacher attitude, values, and behaviour.

As the content, delivery, and context of delivery (i.e., the learning environment) predominantly represent the majority ethnicity, the personal relationship students have with their teacher influences their motivation to engage (Wilson, 1997). Effective teachers recognise the power and responsibility they have to make a difference by,

> caring for the child as a culturally located human being; having high expectations of the learning and behavioural performance of the child; and having high expectations of their own performance, in terms of planning, class organisation, assessment and curriculum knowledge (Bishop & Berryman, 2006, p. 388).

The following stories indicate a spectrum of secondary science teachers; those who demonstrably care about their Pasifika students and want to help them succeed and those who overtly do not.

Values/pronunciation.

Teachers' interactions with their students can determine their success or failure, both by the way they teach and by the messages they convey to their students while doing so. According to the NZC (2007), students will learn what is considered "*important or desirable*" based on the way a set of values, including equity and diversity, are "*expressed in everyday actions and interactions*" (p. 10). Each school demonstrates these differently depending on the school and the community it serves. Nevertheless, many participants perceived these actions and interactions as negative towards their culture, language, and heritage:

> *Naua: they couldn't pronounce my name… [so] I was called 'Tonga'. My biology teacher, sometimes he would point at me because he can't say my last name [laugh], like, 'You!' [laugh]*
>
> *SF: [sigh] and how did that make you feel?*
>
> *Naua: I don't know, I [thought], I am in a new country, so I guess I can take it… so I said, 'You can call me [English name]', because you can actually say it.*
>
> *SF: What did they say to that?*

Naua: They all said, 'Thank God!'

Culturally sustaining pedagogy favours linguistic and cultural pluralism (Paris, 2012), yet, this school's culture (and others) enabled staff to engage with minority students in a manner that devalued their diversity. Rather than learning the correct pronunciation, using the name of his country instead enabled his teachers to maintain their cultural position and diminish his. Such a school culture has significant implications for expectations about the academic potential of Tongan students and their learning outcomes.

It seems almost too obvious to expect teachers not to express their personal views in the classroom, especially deficit views. However, examples of inappropriate comments were reasonably common:

> *[My teacher] was racist. I remember one time she was venting her opinions over scholarships for Pacific Islanders and it was hard for me to take because I was the only one there. She went on a rant about how she understands that Māori deserves scholarships but [not] why Pacific Islanders do, and they should be exactly like all the other immigrants. It was when I was applying for scholarships, so it was hard for me to take in. I didn't know why we did have scholarships, so I couldn't exactly defend myself and the whole scholarship process. I sat there in silence and I didn't want to learn from her from then on (Lupe, ANZE).*

Teachers influence how students respect diversity and the importance of positive relationships with people from different backgrounds (Gay, 2002). Yet, expressing a view with such animosity could very well teach the student cohort the opposite. Not only is this behaviour detrimental to a Pacific student's engagement, learning, and academic outcomes, it creates a learning environment that directly contradicts the NZC's (2007) emphasis on valuing student learner identity.

Equitable approach.

Most KOTE participants described their teachers as having favourite students who became the benchmark for content delivery. The participants felt that if their teachers were more equitable in their approach, it would acknowledge the diversity in the class:

> *[when] you are with the same teacher for the entire year, you are thinking they would get to know a little about the strengths and weaknesses of everyone not just the top. [My teachers] assumed that the smartest people represented the entire class. They didn't put any effort into trying to get everyone to succeed… some of the teachers mostly recognised the top of the class, and the [rest] they*

don't take you seriously, they don't know how to talk to you or to help you which I found a little bit sad (Mele, KOTE).

Culturally responsive teaching expects teachers to believe all students are capable of academic success (Ladson-Billing, 1995). Yet, appearing to project the class' level of ability from interactions with a small portion of students ignores another core expectation that teachers will demonstrate connections with all learners. Teachers who had more equitable approaches encouraged engagement in the learning environment:

[My chemistry teacher] treated every student like they were all at the same level, that was good. It was easy to ask a dumb question because it was the way she taught, everyone was on the same level, if you are dumb, everyone else is… if she gave us something to do, a task or something, she would walk around to every student, not focus on one student which is what I saw in biology. In biology we had [students] that pretty much always came first in that subject at the front table and our teacher never walked around. She mainly talked to them but the [chemistry teacher] walked around and asked everyone what they wanted to know, it was open. Her classes were relaxing… that was probably the main thing. She engaged with every student… she motivated you to work hard and so with that you didn't want to disappoint her, so you worked hard and that was helpful for my success (Mata, KOTE).

Often interactions with teachers were negative. Although inequitable teaching approaches and interactions affected some participants academically, they catalysed others:

My science teacher in high school, she didn't give much effort to the Pacific Islanders in class, which got me into this state of mind where I thought I hated science because of her… I felt left out, we were not as worthy as the other [non-Pacific] students… she wouldn't ask us the questions that she would ask the other students. She would pass us and carry on doing what she was doing with the other students. She wouldn't pay that much attention to us compared to what I saw her paying to other students. Even when I would want help, I wouldn't get a full answer from her… [there were] probably six or seven [Pacific students], but I could tell that they didn't see that they weren't being cared for… and then they wouldn't pay attention to that class or their education, they wouldn't see that if someone cared for your education, you too could feel you can do something with your life… I want to be a [science] teacher so I can pay attention to everyone, not certain people, I want to give back to the students what I missed out on… What she did [crying], what kept me in [science], I wanted to prove to her that we could be as successful, I wanted to prove to her that all PIs could be successful (Kalala, ANZE).

The concern for others that drives Kalala's career choice reflects the collective rather than individualised approach of traditional Tongan education (Kalavite, 2010) and echoes earlier

descriptions of goals driving participants' success. This story also highlights the deficit attitude embedded in this classroom; according to the participant's interpretation, other Pasifika students did not, or could not discern that perhaps their behaviour was triggered by their teacher's low academic expectations of them. Constant exposure to microaggressions often causes individuals to internalise and believe them. If Pasifika students are ignored and treated differently to their peers and struggle to ask questions in the first place, it is no wonder that so few Pasifika succeed or continue in science.

Demonstrating approachability and concern.

Many characteristics demonstrate approachability, particularly genuine caring (Wilson, 1997). For the successful Tongan science learners in this research the perception of approachability heavily influenced their teacher-student interactions,

> *[If] teachers were approachable, even if they sucked at teaching, I would still approach them. [If I did] I would get more from that interaction than from than the past week of teaching, almost like one on one contact time. [If] teachers [are] not approachable, not caring, when I feel they are not interested then I [would] reciprocate that… I switch off (Lashandra, ANZE).*

Caring is especially significant in education, as it has the potential to influence achievement. Three ANZE participants attended two different secondary schools each, creating a natural comparison of their experiences, including the influence of teacher attitude and demonstration of caring. For example,

> *I loved [science], it was good at [School 1], everything was structured, very strict environment [whereas] at [School 2] it was flexible, not as strict as I would've like it. I didn't feel that the teacher cared that much if we did our work and handed it in at the [right] time. I would've liked it to be more strict because then it would give us a reason to complete it… some people didn't complete it or make an effort to complete it and [our teacher] wouldn't mind too much whereas at [School 1], if we didn't complete it we would get punished for it, and they would note down or ask why we didn't complete our homework. [Then] they would ring our parents and say, 'Your daughter or son hasn't completed their homework, is there anything wrong?' …if the students see the teacher doesn't care, we won't care that much [or] put our effort in to completing... (Kalala, ANZE)*

Caring teachers, demonstrated by teachers being interested, expecting success, and giving praise, can moderate previous experiences of negative judgement. (Muller, 2001). Praise was infrequent but had apparent benefits:

> *I enjoy it if I do something that's recognised. For example, if I do well in a test and the [teacher] comes up to me and [says] 'good job', then… I am going to do the same thing for the next test and improve on it and improve on it… It [helps] if someone supports you and acknowledges you and says, 'You've done a good job', or 'You could've done better' (Grace, KOTE).*

Culturally responsive teaching focuses on caring for, rather than about, the academic success of ethnically diverse students (Gay, 2002). This focus actively engages educators, so they realise their responsibility to achieve student success rather than just expressing concern. The type of teacher-student relationship demonstrates caring; a lack of connection suggests that teachers do not care (Wilson, 1997). Some KOTE participants felt that effective teachers demonstrated caring by initiating student-initiated interactions: *They [show they] want you to pass the papers… they come to you and ask if you need help, instead of sitting there waiting for students to go ask them (Fatai, KOTE).* Effective teachers were:

> *engaging. In terms of making sure your students know what you're doing and what they're doing, and making sure they understand the basic concepts… Sometimes it can be hard to be the first one to ask for help, so [if] the teachers offer to help constantly, [are] always asking you when you leave the classroom, 'How are you going? How are you going with your work?' I know the first couple of times will be hard because we will be very reserved but if we can see you are trying to make the effort to engage with us then we will make the effort to engage… (Grace, KOTE).*

Extra sessions.

Teachers can personalise the learning environment and make it more positive by providing additional time to at-risk students (Owings & Kaplan, 2001). Although not well researched elsewhere, several ANZE participants described spending extra time[43] with teaching staff as creating another, often more useful, space for their learning:

> *I did [better in] chemistry than biology, because I found it more interesting… my [biology] teachers were teaching at university-level, they were lecturing it to us, they weren't even explaining it, they were way too smart, using language I didn't even understand. They just gave us the textbook to go study at home and I didn't know how to use it. It wasn't beneficial to me, whereas my chemistry teacher was involved. She would stay behind class to help me because she knew I wanted to be a doctor, so she was passionate, she helped to tutor me and stuff like that, [that's]*

[43] In other research (see Owings & Kaplin, 2001), extra time is flexible but formalised, occurring in evenings and weekends.

probably why I enjoyed it more (Sina, ANZE).

Instead of teaching 'at-risk students' less or easier content over a longer timeframe, spending more time with them will improve their performance (Southern Regional Education Board, 1994). The participants in this study indicated that extra time could include interactions such as informal conversations after class. Willingness to spend more time with students also demonstrated approachability and caring:

> *[Teachers] that genuinely want you to understand and to pass, they do more than what it's required of them, they make an extra effort to help. We had this homework centre at high school, two of my science teachers would come to that and help and offer to help during lunchtime or if we asked questions, to not brush us off (Lashandra, ANZE).*

Extra help also meant that students enjoyed their studies more:

> *SF: You said you enjoyed bio and chemistry more than physics?*
>
> *Manu: My teachers were better… They took the extra step, they gave us extra homework, extra tutor classes.*

Feedback.

For many participants, the type and frequency of feedback was a significant aspect of the teacher-student relationship. Effective teachers reflect on student achievement with their students, forming a collaborative relationship that allows the teachers to improve their teaching practice and the students to learn how to monitor their academic development (Bishop & Berryman, 2009). According to Hattie (2003), excellent teachers provide feedback. However, most participants received little or no individualised academic feedback on their achievement:

> *I remember this one time, it was at the beginning of the year, I studied hard for one test and I got a few things wrong, but [my teacher] wasn't clear what I got wrong, so after sitting that test the entire year went downhill for me (Mata, KOTE).*

For the few students who did receive direct feedback, it was evident that this improved the teacher-student relationship because it demonstrated that the teachers cared:

Jake: …a lot of my high school teachers when I did not do so great in a test, they would give constructive feedback and sometimes they would offer to give a tutorial after class to go through the paper, I thought that was helpful. But… knowing the people that are teaching are interested or care about your grades and what you are learning is a big factor in making you engage…

SF: How do they show they are interested?

Jake: …caring about what your grades are, so if you are not doing so well, giving you feedback and going through the paper, [that] makes me feel these guys want to me to do better … that [teaching staff] would approach me gives me a sense, a feeling that they care about my grades and want me to do better, because if they gave me a grade and its crap and they left me it's like, 'What's your job? You haven't taught me anything'

Implications for Science Teaching

While analysing my research findings and reading about Ladson-Billing's (1995) culturally relevant and Paris' (2012) culturally sustaining frameworks, I reflected on how, and if, my teacher practice aligned with these frameworks. Culturally relevant teaching aims to improve academic success and ensure that learners and teachers/educators have cultural capacity and can critique the world around them. Culturally sustaining pedagogy emphasises cultural pluralism, requiring pedagogies to be responsive and relevant to multi-ethnic communities, support young people to maintain their cultural and linguistic competences while building cultural competence in the dominant culture.

In my practice, I strive to be critically self-reflexive. Nonetheless, I know that I have much to learn about Tongan and other Pacific cultures and teaching, as despite commonalities across the Pacific region, there are also cultural differences. What I am sure of, though, is that even small changes can have significant impacts on teaching and learning spaces. I am also very aware of the generation gap that exists between most of my students and me. Thus, I recognise that I must give them ways to demonstrate what they know and how they see the world. In the example I share below, I outline how I have embedded Indigenous values, culture, and knowledge into an assessment that also enables students to demonstrate who they are.

Using video to embed Indigenous values, knowledge and culture into science assessment.

The current TES expects the tertiary sector to create learning opportunities for Pasifika students to be able to engage with their cultures, with the intention that this will assist with Pasifika retention, success and connection to their communities (Ministry of Education & Ministry of Business, Innovation and Employment, 2014). As described earlier (see Chapters One and Four), previous research indicates that Tongan students' engagement increases in learning contexts that reposition Tongan ideas and practices as central to learning by using Tongan language, culture, and values (Manu'atu, 2000; 2009). Including Tongan scientific knowledge in the curriculum would also increase the relevance to Tongan students (i.e., culturally relevant pedagogy). Also, core elements of Tongan culture can be used to transform the learning environment, including recognising the importance of group work in Tongan culture and making it an effective teaching and learning method to emphasise in the classroom ('Otunuku, 2010).

As a result, I have designed an assessment for students to create their ways of telling, teaching, and explaining the course content. In small groups (usually three, maximum four) they create a dynamic model in any medium (i.e., animation, game, dance, song) to teach a course learning objectives, using their cohort as the target audience (see Fonua, 2018 for more detail). This assessment showcases student culture and encourages them to actively learn an essential concept so they can teach it creatively. They are encouraged but not expected to use IK in the interpretation or delivery of a teaching tool. Nonetheless, they are expected to consider their Indigenous and youth perspectives. Students are encouraged to foster an appreciation and pride of their IK, languages, worldviews, teachings, and experiences through their Indigenous science learner lens. I believe this assessment reflects a culturally sustaining pedagogy as it recognises,

> the dynamic, shifting, and ever-changing nature of cultural practices. In thinking about sustaining and extending the cultural practices and ways of knowing of students marginalized by systemic inequalities based on race, ethnicity, and language, it is important that we do not essentialize and are not over deterministic in our linkages of language and other cultural practices to certain racial and ethnic groups in approaching what it is we are seeking to sustain (Paris, 2012, p. 95).

Anonymous student feedback shows that students find the assessment helpful, engaging, and fun. Overall the current students enjoyed group work because it helped deepen their understanding, often sharing useful analogies. *Māfana* becomes embedded into the course through the humour used in these models. Most of the videos appeal to the student audience, using fun and culturally relevant stories that speak to the students and their realities. For example, using the cultural differences around dating for Pasifika and *Pāpālangi* girls as an analogy for the different cell signalling pathways. Although *māfana* is a Tongan concept, it is one that translates well to others, and as Manu'atu (2000) suggests, it is a feature that combats the seriousness of the content. The best models are those that demonstrate an understanding of student contexts, an understanding only they can have. So, instead of expecting students to navigate the learning gap so they can achieve, I am encouraging them to help me navigate the learning gaps in my course. Thus, I have transformed my learning approach to engage Tongan and other Pasifika students better so that they can enjoy and be successful as science learners.

Concluding comments

According to Ladson-Billing's framework, effective teachers create learning environments where there are positive relationships and interactions, power imbalances are acknowledged and addressed, a range of teaching practices is employed, student prior knowledge is valued, and there are high expectations of all students and themselves as teachers (Ladson-Billings, 1995). If teachers can meet these goals, student achievement will improve. However, many stories in this research described negative interactions between Tongan (and Pasifika) science learners and their teaching staff and student cohort. The participants often spoke about experiencing or witnessing prejudicial norms, values, and actions in their secondary school(s). Concerningly, inappropriate and inequitable academic preparation hinders students' successful advancement and engagement in each successive level of Aotearoa New Zealand's education system (Middleton, 2008). Unfortunately, even if the participants demonstrated[44] academic ability in science or self-efficacy by actively trying to select science subjects, they had to negotiate with a deeply embedded negative Pasifika science learner identity to realise their goals in science. Thus, for the most part, it appears it

[44]Not all of the participants realised their potential in secondary school science. For some, only after experiencing a positive learning environment during their university foundation studies was their actual academic ability realised.

is the school culture and the teaching staff that need to adjust so that Pasifika students can achieve their true potential.

Chapter Eight – University and science education in Aotearoa New Zealand

More students with an increasingly diverse background and exposure to content knowledge are attending university (numbers have doubled since 1991). The widening access to university study has had implications for teaching and learning in the university system, as students become less homogenous and staff deal with larger classes with less funding (Roberts, 1999), often drastically affecting teaching ratios. Furthermore, the increased range of ability and academic preparedness within the current student body requires more diverse approaches to teaching and learning methods and assessment (Biggs & Tang, 2007). This chapter explores the experiences of successful Tongan science learners at university with the aim of informing the system about what it means to be a Tongan science learner at university and which teaching and learning methods support their engagement, enjoyment, and success.

Organisational culture & climate

The University of Auckland is 'NZ's leading world-ranked university' and the largest. In 2015, there were 42,100 full and part-time students and Pasifika students were the third largest ethnic category: Asian and Pākehā/European students made up almost 40 percent each; Pacific peoples almost nine percent; and Māori almost eight percent (University of Auckland, 2018). These numbers do not reflect the ethnic composition of the Aotearoa New Zealand population: both Pacific peoples (7.8% of the Aotearoa New Zealand population) and Asian students (12.2%) are over-represented; Māori (15.6%) and European (74.6%) are both under-represented. However, this simplistic comparison overlooks the level of study (undergraduate vs. graduate) and describes the whole university student population rather than a more specific ethnic breakdown by Faculty. It is likely that the Faculties of interest to this research, Science and Medical and Health Sciences, have considerably smaller numbers of Pasifika students, particularly in the Medical and Health Sciences, and that enrolments in other Faculties such as Arts and Education and Social Work inflate the University's Pasifika student numbers, but the numbers are not publicly available.

University mission statements often suggest an emphasis on equity, yet universities are known to structurally "devalue, ignore, invalidate, or treat as peripheral the needs of non-traditional students" (Moses, 1990, p. 403). Furthermore, the difference in what is proclaimed by a university for its students and what the values and structure of a university allow can make it hard to retain students who feel that the culture of the system does not fit them (Moses, 1990). The university must provide services or other methods to support non-traditional student engagement rather than assuming they will engage with the institution (McInnis, 2003). The culture of this support can often be determined by the type of learning environment, measured by how well the institutional culture welcomes diverse students, provides a variety of support services, and adapts to student expectations (Zepke & Leach, 2010), and how well they are retained (Benseman et al., 2006). The University acknowledges Pasifika students are an equity focus in a variety of ways, including the objectives and values of the Strategic Plan 2013-2020, and Pasifika-specific staffing appointments, such as the Pro Vice-Chancellor Pacific initiated in 2018. Nevertheless, the narratives below suggest that the University might need to consider its relative performance in enabling Pacific, and specifically Tongan, students to feel more welcome and feel a sense of belonging.

University science.

Recent research on Pasifika learners and success in tertiary education has highlighted appreciative pedagogy, teaching and learning relationships, and institutional commitment as educational and organisational practices that contribute to student success (Chu et al., 2013). Nonetheless, there is limited research on the teaching and learning context of science in Aotearoa New Zealand universities, particularly for specific ethnic groups such as Tongans and what keeps them engaged, enjoying, and successful in science at university. Traditionally, university science is taught in three different learning environments: the lecture, practical laboratory, and tutorial, all of which are very different from the secondary school experience of science (Forret et al., 2007). The following three sections of this chapter present and critique the participants' experiences of lectures, practical laboratories, and tutorials at university. Key themes from each draw attention to the participants' views about the utility of small-group learning in science and the importance of acknowledging cultural values in the delivery of science education. Later sections focus on how Tongan cultural values are acknowledged or contradicted, and the complexity of Tongan science learners' lives.

Lectures & Lecturers

Despite an increasing emphasis on the quality of teaching at university, and a shift to learner-centred approaches, the mass lecture is still the most common teaching approach in tertiary science (Watters & Watters, 2007). Interestingly, most university teaching staff have no formal teaching qualifications (there is no national requirement for formal qualification) and rely heavily on the teacher-centred/didactic method of their educational experience and training. Lectures are very effective at disseminating the large amounts of content knowledge that university science courses contain (Campbell, Knnemeyer & Prinsep, 2008). However, they can force many students to "adopt beliefs that knowledge and learning involves the accumulation of information and the capacity to reproduce on demand in examinations" such as rote learning and memorisation (Watters & Watters, 2007, p. 19) and prevent relationships forming with students. Many researchers have documented the importance of relationships for Pasifika students (for example, Anae et al., 2002) but little is known about successful Tongan university science learners. The narratives in this section give a strong indication of how influential interactions with lecturers were for the participants and how crucial it was for their engagement and success to get these interactions right. They highlight how the structure, capacity, and expectations of the learning environment, particularly in lectures, limit opportunities to build relationships and interact with teaching staff at university.

Lecturer availability (teacher-student relationship).

For many ethnic minority students, positive relationships between them and staff have been shown to increase retention and success (Johnson et al., 2007). For Pasifika student success at tertiary, a key element is the teaching and learning relationships formed with teaching staff and peers (Chu et al., 2013). How students interact with their teachers has obvious consequences for their academic engagement, enjoyment, and success. As the narratives below attest, these relationships influence how successful Tongan students communicate, engage, and interact with their university teaching staff. For example,

> *There are lots of lecturers that you don't [engage with] because they are rushing…. There are lecturers who are there for the hour, and they want to leave. Students can tell if lecturers are engaged or not. I know lecturers' have their research and stuff to do, but… if they are going to lecture [they should] make the students feel that they are there to lecture and help them (Grace, KOTE).*

Prior research has highlighted the "vexed relationship between research and teaching" within universities (Lindsay, Breen & Jenkins, 2002, p. 310). Although there is a necessity for lecturers to be research active, students note the negative impacts on lecturer availability and focus on teaching. The University's mission statement states that it will be "recognised for excellence in teaching, learning, research, creative work" (University of Auckland, 2012, p. 3). However, the stories in this research often questioned the quality of the science teaching experience:

> *[We have had] boring lecturers, monotone lecturers, lecturers that didn't seem interested in what they are doing. They say they are there because [they] were asked to come, they didn't want to come… Sometimes they say it, 'No one wants to teach this, so I was the one they put on the list to come'. When they say that first, maybe I don't want to be there either (Naua, KOTE).*

This story is hugely concerning and demonstrates issues of professionalism. It may also be reflecting the reality of an organisational culture focused on research, or at least one that does not value teaching, despite the mission statement. Naua's story also reveals how students can easily be disengaged from their studies by their teaching staff. Large class sizes also disengaged the participants and affected their access to teaching staff, especially if the student preferred face-to-face conversations:

> *It was a lot harder because the classes were so big. In Year 1, I didn't engage with staff. Straight after a lecture, they're trying to get to their next lecture, there isn't much time. I am a face-to-face person. If I email and I get a response, that doesn't mean anything to me… having that opportunity to have face to face conversation [is important] (Lashandra, ANZE).*

Large classes also influenced whether they asked questions or for help:

> *I know that emailing a lecturer… 'Oh, another one of my 500 students', so I [don't]. I know they are lecturers, so they are busy, they teach other courses. If it was a difficult question I would, but most of the time I find the answers… I would find another resource, internet, textbooks… (Takai, ANZE).*

While demonstrating essential independent learner skills, their approach is a response to their impression of lecturer access.

Asking questions is a crucial aspect of student behavioural engagement (Fredericks et al., 2004). It allows students to test how well they know their content, develop analytical and reasoning skills, and to grow socially and emotionally (Cundell & Pierce, 2009) and to demonstrate critical thinking. Feeling unable to ask questions, impacts on the development of these abilities and comprehension, and the opportunity for feedback. Hearing lecturers criticise other students' questions can cause them to disengage. For example,

> *I had this lecturer last year, I stopped going to his classes, because I felt dumb… He used so many hard words, and he expected us to know it. If you asked, 'What is it?', instead of giving you the answer straight away, he would make a little comment, 'Oh, you don't know it? You should know this by now', instead of taking into consideration that we all come from different schools and we all learn different things. That discourages you, and you don't want to ask any more questions. When he says that, and then the whole class laughs, it's not a pleasant feeling and you don't want to turn up to that class anymore… I stopped going and that didn't affect the lecturer, it affected me. I barely passed that topic, and it was an easy topic… but because he made it complicated, and he expected us to know it, you feel, 'Oh, never mind, there is no point' (Grace, KOTE).*

Some participants suggested that teaching staff should be more proactive in their engagement with Tongan students:

> *Talanoa, talanoa to us, open the floor to us to let us talk to you. Don't expect us to come to the teachers all the time because sometimes we don't know what to say… coming to talk to us, after class, during class time, lets us know that you want us to achieve. Ask, 'Do you understand? Is there anything I could help with?' …they might answer 'Yup, yup, yup, we understand' but… follow up on them, 'Is there any other questions?' Eventually, they will open [up] because they see the lecturer is genuinely interested and aware, then they would engage… there is [variability] in personality, some students are very accepting, other students don't want the teacher to notice [them]. It's hard but… it's asking them and making sure they are aware that you are there to help them (Grace, KOTE).*

The Science Lecture.

The preference of teacher-centred delivery in science has been well-debated, with many favouring a shift to styles that encourage more active-engagement learning, particularly for underrepresented groups (Freeman et al., 2014). Lectures are often critiqued for being unengaging, placing an over-emphasis on memorisation and for creating a one-way form of communication, whereas delivery with substantial student input and discussion is argued to do the opposite (Beishline & Holmes, 1997). However, these researchers also

found that students prefer lectures as a form of content delivery, as long as other techniques are embedded; they "specifically dislike lecture only classes, lectures with required student participation, mainly student discussion groups and class presentations by other students" (Beishline & Holmes, 1997, p. 95). In general, the participants' stories agree. For example,

> *Sitting in a lecture theatre with two big screens, not talking to [students], or being given the time to try and do examples on our own, when the lecturer is telling you, 'This plus this equals this' or, 'When you swallow the whatever…', being told that, doesn't make it enjoyable… There must be some visual aids or time to have an example and work through it on our own (Lashandra, ANZE).*

A recent study indicated that students found chalk/white-boards are more useful for exam review, comprehending material, and significantly, keeping student attention (Rudow & Finck, 2015). Most participants in this research criticised the overuse of PowerPoint presentations and lecturers reading the slides:

> *I like when lecturers don't use PowerPoints. They use the course guide and they go through it and they highlight, or they draw pictures and they use other examples to explain… clinical examples, I like those. I don't like PowerPoint. Heaps of lecturers, they say what's on the slide… [and] they use language that I don't even know what they are talking about, so they are not explaining it. Whereas when they go through it with you... I understand it way more when they do that, so when I go away to make my notes I remember 'Oh, that's right, they said that' (Sina, ANZE).*

'Good' lectures.

Like many terms in education, there are numerous phrases used interchangeably to refer to 'good' teaching, for example, effective teaching, successful teaching, or teaching excellence. Nonetheless, good teaching depends on individual perception, as influenced by "cultural considerations, personal preference, and how the teacher and learner/s feel at a given moment." (Derounian, 2017, p. 9). Furthermore, Derounian acknowledges there are "cultural differences as to what may be seen as acceptable, let alone inspirational, in university teaching and learning." (p. 3).

Increasingly diverse university student cohorts require a review of teaching and learning practice, and acknowledgement of different abilities, capabilities, and prior knowledge (Roberts, 1999). Providing alternatives to the traditional lecture format, especially

those that encourage discussion and collaborative learning with peers, has been demonstrated to increase student engagement and achievement for minority science students (Preszler, 2009). However, this does not make lectures redundant. As indicated above, the lecture is a vital learning setting; perhaps it needs to be better informed by students' voices?

Using mixed media and interaction.

Most participants preferred mixed delivery approaches, particularly to engage them in large classes. Using methods that broke up the lecture delivery and allowed student interaction helped engagement and provided ways to determine their understanding:

> *Some lecturers like to ask people [questions] on the spot. Even though it freaks me out, it's something that works for me, questions and answer sessions in class... I don't put up my hand, but I whisper it to myself and compare that to what their actual answer is later (Setaita, KOTE).*

However, the specific technique employed was significant as some KOTE participants struggled with small-group work because of language issues:

> *Group work isn't that enjoyable [because of the language barrier] but getting us to do stuff as a class [is] great. For example, [online resource], we were doing it in [lecture] and we use the [online platform], they ask us questions, they give us scenarios and they give us chances to go around the group and talk, not giving you a group (Vaea, KOTE).*

Online engagement tools that provide anonymity are particularly useful as they provide personalised feedback to the learner immediately:

> *I like that [online tool], because it gets you into the material at the beginning of class. …It focuses all your thoughts on the question that you are doing before class starts so you are already focused… and then some during class. That was cool, it told you if you knew the answer or not, which told you if you need to study or not (Avila, ANZE).*

Visual aids.

Recent research has indicated that practical applications have different impacts on achievement; for example, practical models had a stronger academic impact than organ dissections or virtual labs (Lombardi, Hicks, Thompson & Marbach-Ad, 2014). Using visual

aids can also cater to different learning styles and create opportunities to apply content in another way:

> *This lecturer was good, he was teaching us muscles. It was a boring lecture, but he brought in models. His lecture notes [had] gaps to fill in and questions. When it came to the muscle, he would use models to show where it was... What he was teaching was intense but the way he taught us, he had the models to help us visualise… that was a good lecture (Mata, KOTE).*

Diagrams were especially valuable for learning science:

> *I like teachers who use lots of visual data, diagrams, they help me with my understanding. I like it when they have diagrams in the coursebook, so I can annotate them, that helps me …understand what they want me to know (Inoke, KOTE).*

Assuming prior knowledge and understanding.

Bain (2004) has previously described excellent teachers as willing to explain and tell the whole story while less accomplished teachers make references to information and give brief overviews, often missing key aspects. It would seem the participants experienced several of these less accomplished lecturers. Understandably, the participants found teaching staff who assumed student understanding or prior knowledge a hindrance to their learning:

> *I like when teachers don't assume you know things already, I like it when they teach a subject, they give background information beforehand. [Our] lecturer now, he is teaching us, and to be honest, it's like studying things we have never studied before. It's supposed to be a compilation of everything we did last year, but the way he talks about it, there is a lot of stuff that he thinks that we already know, but we don't. That doesn't help, and he talks fast… that's not helpful either (Katinia, KOTE).*

Increasing content relevance can help build positive emotional and cognitive connections and increase understanding (Grabau & Ma, 2017). For the participants in this research, the relevance and depth of content helped them engage:

> *Learning more about biology, about the cells and how the body works, I need to know that because when something happens in my family, [I can explain] 'Oh that's not working because of that'. I enjoy that. Knowing what drugs do to your body and what you could do to prevent that, I took [that course] because my brother is the only smoker in my family, so I took it hoping that I could use it to manipulate him to stop smoking (Fatai, KOTE).*

Passion*, mālie and māfana.*

While acknowledging that good teaching is hard to measure, some researchers have developed frameworks that outline areas of excellence for teaching (for example, Wood & Harding, 2007). One area was 'Attitude', which encompasses demonstrating enthusiasm for teaching, being inspirational, accommodating, and pleasant to students (Wood & Harding, 2007), all of which were important for the participants in this research. Inspirational teachers are passionate, memorable, motivating and encouraging, and able to stir enthusiasm and capabilities in their students (Derounian, 2017); the participants described many of these features in their stories of 'good' teaching.

Participants in both groups often described how teaching staff delivered science content, particularly comparing 'passionate' and 'monotonous' deliveries. Overwhelmingly, passionate teachers who make the content relevant and relatable helped engagement and enjoyment:

> *If they have passion for it and they had the willingness to teach us and want us to know information, that's what got me engaged. …If lecturers are passionate and they love what they learn, they want to teach, that's a big thing for me that makes me understand. I have experienced so many teachers and lecturers… that don't show passion, it's hard to concentrate and want to understand their stuff…seeing them interested in what they are telling, seeing passion in [the lecturers] is the biggest thing that makes me engaged… (Katinia, KOTE).*

Believing that the lecturer wanted to teach them was important for all participants, which they felt was indicated by how the lecturer presented their content, including demonstrating passion for their topic and considering how they relate to their audience. For example,

> *Often… their presentations were boring, it looked like they do it every year… and doing the same speech. It's not engaging, they shouldn't be monotone... you want a balance, you trust the information they are giving because they are professors, but we also want to enjoy the lectures so they could do it less professionally. One lecturer, she seemed uninterested, but that's her job! Is it a requirement for teachers to be interested? …if the teacher is interested, it gets the student to be motivated, and they would want to come to your classes and learn about what's happening. We had this new lecturer this year. He's my favourite one in med school…, he's done acting lessons to be more engaging! He would go to the students' level instead of other lecturers who tend to be the older ones, who give lectures in a way that's not interesting to us, maybe they are used to delivering lectures like that? (Soana, KOTE).*

Manu'atu (2000) described how *mālie*, a process connecting the mind and body during performance, helps energise and transform. It is possible to interpret aspects of *mālie*, or the beginning of *mālie,* as a transformative process in these stories, for example, how the energy of the last narrative changes when the lecturer engages in a more performative approach. Manu'atu (2009) also suggested that acknowledging the importance of *māfana* would increase Tongan science learner achievement. *Māfana* is a euphoric feeling that captures a person mentally and physically and makes them more open or able to participate or engage to a greater extent. If triggered in the teaching and learning environment, it can be energising, engaging, and could potentially increase understanding.

Mālie and *māfana* are experienced during a performance, when the interaction between the performer and audience produces an opportunity for real engagement and creativity (Manu'atu, 2000). If triggered in the teaching and learning environment, it can be energising, engaging, and could potentially increase understanding, as demonstrated in the story told above. This analogy follows for lectures, as the interaction between the lecturer as the performer, and their student audience are essential to inspirational teaching, and learning experience (Derounian, 2017) as the rapport between the performers and the audience is important (Manu'atu, 2000).

The KOTE participants often commented on how teaching staff being 'funny', and the 'fun' aspect of teaching was helpful for their learning:

> *I found it fun because we used colour and at the same time, I understood it. I enjoyed it more because it was entertaining because we had to colour in at the same time, and I understood the information… going through the lecture together and filling in blanks and highlighting stuff, that was cool, watching videos, that kept my interest going and made me want to pursue science, oh, the labs definitely! (Avila, ANZE).*

As the topic came up so often, it became necessary to clarify what 'fun' meant:

> *'Fun teachers' [are] not boring… interesting, and if they make jokes and you are laughing. It's not a chore to be in the lecture … you don't necessarily have to be laughing… it could be if you are doing activities that relate, and you are enjoying it, [then] you would learn better, or remember it (Malia, KOTE).*

This is a significant point; rather than assuming fun equates to humour or laughter, such as playing games, enjoyment is more complicated. It can involve individual enjoyment or enjoyment of activities with peers, and is linked to interest and relevance, as well as when students feel competent and rewarded for their effort with understanding (Grabau & Ma, 2017). Determining 'enjoyment of science' is crucial as it influences engagement in science and science achievement (Osborne et al., 2003). There are calls for a better understanding of the association between knowledge and enjoyment for students of different cultural backgrounds, particularly as research indicates enjoyment of science is central to retention (Ainley & Ainley, 2011; Grabau & Ma, 2017) and can affect achievement.

Laboratory classes

Practical learning opportunities are essential in science education, providing a unique teaching and learning environment for scientific discovery and inquiry-based learning (Hofstein & Lunetta, 2004). While lectures predominantly deliver content to passive recipients, (Biggs & Tang, 2007), practical laboratories are a valuable way to integrate the theoretical and practical science content, to deepen understanding and interact and build relationships (Forret et al., 2007; Campbell et al., 2008). All hard science courses (i.e., biology, chemistry, and physics) at the University have laboratories, creating opportunities for students to check their understanding of complex theoretical content, often in a more tangible or applied way. The University's laboratory resources made a difference to enjoyment and understanding of science content for the participants, particularly the models and specimens which often made concepts more tangible and visible:

> *What makes me even more interested and engaged is all the stuff that uni has. In the labs, you get to see different equipment that we never had in Tonga. It makes you want to touch it and check it out… and you can imagine there's incredible stuff in science that you want to get to know more about. It makes you want to engage more in knowing the details. I like playing around [and experimenting] (Vaea, KOTE).*

According to Gallagher (2000), "both making sense and making connections are essential elements in forming understanding" (p. 312). Yet, making connections and understanding content is not usually emphasised in secondary school science, making dealing with the vast volumes of content students encounter when they transition to university

overwhelming. Being able to apply content knowledge practically helps engagement, enjoyment, and understanding:

> *When we do practicals, learning clinical conditions and problems… I understand it so much better than when it is taught in lectures. When it's put into a practical sense, when we are taught it and it's not a one-way thing, we must use our minds and stuff to try and figure something out and do things with our hands. That helps, that gets me engaged, it makes me enjoy it (Katinia, KOTE).*

> *What I love, what I enjoy about science is labs… labs are the interesting part, because I don't like studying sometimes, just looking at notes, but doing the whole practical, sometimes it's fun. It's not fun when it comes to writing up your lab but that two to three hours that you spend in the labs, that what I call enjoying science (Vaea, KOTE).*

Labs encourage making connections and provide opportunities to learn in a less formal environment:

> *The practical labs… force us to put things together, the theory with practical, once you put them together you get why you are learning it …when you have an understanding, you enjoy… [also] getting up and not sitting, in classes, you sit, and you might do individual work, but in a practical setting, you can ask your friends to join you or, it's less formal (Soana, KOTE).*

Access to teaching staff.

The lab learning space enables different interactions with teaching staff, such as lecturers and demonstrators, that did not occur elsewhere:

> *The labs [helped me enjoy] because I get to talk to people and work with them as well, get to know them a bit more… I like interacting with other people. We have our actual lecturer come in [sometimes], and I find that quite helpful because you can talk with them… you don't get that much, only in labs. (Laulotu, ANZE).*

Lab demonstrators[45] often play an influential and essential role in the learning experience as they have more direct contact with students than the lecturers (O'Toole, 2012). For example:

> *Some lecturers are good at talking to you at an undergrad level of knowledge, [others] can't talk to people. It's hard to understand them at times. But lab demonstrators, some of them are undergrad, they understand, they probably did*

[45] Lab demonstrators (usually post-graduate students) are employed to assist students in labs by answering student questions and guiding students through the lab class.

> *the course as well, [its] easier to understand them and approach them, than a lecturer who is way up there… (Mele, KOTE).*

Working with lab partners raised some concerns. The lab partner dynamic makes for an interesting relationship, particularly as lab partners do not generally know each other beforehand, and the success of this partnership has implications for academic results. Some research suggests that pairing students of different academic abilities helps enhance peer learning, where both students learn from each other, thus increasing understanding (Miller, Witherwow & Carson, 2012). Perhaps university teaching staff could help negotiate these relationships by allowing students to have time to meet each other as this story suggests:

> *Being cut off from the rest of my study group, not having someone I knew with me [was hard]. In labs they introduce themselves and tell us to start the work… maybe a few minutes for us to get to know each other, to know the person beside you? They expect us to be in the lab for twelve weeks and by the twelfth week you still don't know each other. [In] one lab and I didn't know [the person] until the twelfth week [laugh]. It would have been helpful if we had known each other from the beginning, it would've been helpful for us working together (Inoke, KOTE).*

Tutorials and small-group learning

Academic and social experiences of higher education have implications for retention and degree attainment (Johnson et al., 2007; Tinto, 1993). Often lectures did not host positive social experiences or enable asking questions. Encouraging active learning in learning spaces helps minority students' formal and informal contact with staff and encourages better collaborative work with peers (Meeuwisse, Severiens & Born, 2010). Overall, the participants found tutorials and small-group work supported their learning:

> *Tutorials help me way more at uni, just carrying on what I liked in high school, I don't like lectures, I don't learn much in lectures, I learn more, like 80% of my learning, in tutorials or groups (Naua, KOTE).*

> *…another thing I love that makes me engage, is having small groups. I love doing things in small groups. We have different sessions about different things, and it's nice to have a smaller group because you feel more comfortable to share, it's nicer in a smaller crowd. Group learning is great. I engage most in group learning; that's the times I enjoy most (Katinia, KOTE).*

Tutorials are scheduled classes involving "small group discussions that focus on some aspect of an academic discipline and which are customarily led by a lecturer" (Anderson, 1997, p. 184). Nowadays, it would be highly unusual for lecturers to run tutorials. In general,

tutorials and tutors are perceived as an easy target for cost-cutting in higher education. However, reducing the opportunity for small-group discussion has negative consequences for student achievement, with an often-detrimental effect on student learning. Although, in general, science courses do not have tutorials, they do occur as part of the University's affirmative action programmes, and the medical programme does also include some small-group teaching.

Some participants struggled with small-group learning because they did not know anyone and needed time to feel comfortable:

> *…My study group would be enrolled in different [streams] …not having some of them with me, sometimes I would get nervous if I am by myself. If it's a group activity, I would mainly sit back, not saying much but trying to suggest something in group work (Inoke, KOTE).*

Tutorials needed to be safe spaces where students are comfortable to ask questions:

> *In tutorials, people who already know the basics come and ask for help with the hard questions, that stops people who want to know the basics from asking questions. It's establishing an environment where you can ask even the littlest questions. It's not emphasised enough. You need to make us feel comfortable, so we can ask (Grace, KOTE).*

Rather than Tinto's often critiqued concept of integration for retention and achievement, focusing on a student's sense of belonging or connectedness can highlight the relationship between the student and the institution and shifts the power dynamic to one that is more equal or mutual, (Johnson et al., 2007). This differentiation is an important one to consider when using group work or encouraging students to study or learn together. The academic and social benefits of collaborative peer academic support indicate that higher education should "be more intentional about encouraging students to form study groups, especially in STEM classes[46]" (Sandoval-Lucero, Blasius, Klingsmith & Waite, 2012, p. 31). Yet, it is worth considering whether students are being asked to fit into these groups to fit the system, or if the system could allow students to form groups where they feel that they belong, or an approach is used to help them feel that they belong?

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Springer, Stanne, and Donovan's (1999) meta-analysis of small-group learning in STEM subjects found a positive effect on achievement, persistence, and learner attitudes. The impact on achievement for minority groups was more significant if the groups are homogenous or they were the majority ethnicity in the group. Tutorials that incorporate teaching approaches that identify with Pacific values and demonstrate the importance of Pacific cultural capital, or 'polycultural' capital (Mila-Schaaf & Robinson, 2010), return some power and legitimacy to the students. These classes demonstrate the value of their cultural context within the context of the institution:

> *I think group work, more collective activities, I feel that there is strength in group work, strength in numbers (Lashandra, ANZE).*
>
> *Because Islanders are community people, being able to interact with friends in the same course and stuff [is important] because we like being around people… (Avila, ANZE).*

Springer et al.'s analysis indicated it was not a particular method[47] of group learning that benefited student achievement; rather, it was its implementation. Even minimal small-group learning had a positive effect on attitude and achievement and was shown to improve retention. But assigning students to groups for the sake of group work is not the same process as embedding cooperative learning.

Cooperative learning, when students work together rather than individually or competitively, has long been shown to have a beneficial impact on the academic performance, confidence, and sense of belonging of minority students in introductory biology courses (Posner & Markstein, 1994). Cooperative learning can also help with transitioning, develop analytical skills, and increase retention in subsequent science courses.

Studying with other Tongan (or Pasifika) science learners.

Earlier research indicates that Pasifika students find their peers have both positive and negative influences on academic achievement by offering support as well as social distractions (Benseman et al., 2006). In my research, all participants described the positive

[47] There are various types of small-group learning. One form, cooperative learning, ensures that a group is working towards a common goal, with all members being accountable and playing a role, whereas collaborative learning involves group members negotiating an unstructured process to define issues and develop responses (Springer et al., 1999).

impact of their friendships; only one participant indicated their peers distracted them from their studies to the detriment of their academic achievement. The value of studying and working with other students was a common theme amongst the participants:

> *Mainly, I study by myself …then when I go to my study group I try and revise the work that I have remembered to see if I understood it; they explain what I don't understand. The group work with my friends engaged me more, involved me more. When I am by myself, I tend to lose that concentration, but when we study in a group it's fun, it makes me get involved, its more enjoyable for me (Fifita, ANZE).*

Previous research has indicated the influence of culture, whether individualist or collectivist, on learning styles and approach to learning (for example, Hofstede, 2001). Working with others providing benefits beyond the content understanding, such as support, motivation, and other ways to study:

> *…Having a good study group. If you are not that keen to study, then someone else is… we sit down in a group, and we will discuss what we think. We get different perspectives, and then even if we get it wrong, we know what everyone was thinking. Sometimes you lose focus… it keeps your motivation going. It's good to have friends that are in the same boat as you (Kava, ANZE).*

Many of the stories that follow highlight the collectivist values of reciprocity, cooperation, and sharing, common among many Pasifika cultures (Thaman, 2003). The KOTE participants particularly appreciated being able to help each other:

> *Working with your peers and colleagues, it's fun. If you all have the same interest and you are working together, maybe helping each other as well. [If] you are trying to explain something to someone and they didn't get it, once they get it, it's enjoyable watching them succeed as well (Naua, KOTE).*

Pasifika students often prefer to work collaboratively, allowing them to share knowledge so that all students participate and learn. This approach has many benefits, helping students to reach the same level of understanding (Mila-Schaaf & Robinson, 2010) while supporting those who are shy, lacking confidence or academic background, which also helps with their retention (Latu & Young, 2004). Working with other Tongan or Pasifika students in study groups helped them feel less culturally isolated in their learning:

The study groups [helped], especially with first-year… because when I got to university, I felt removed from my culture, especially first-year. I felt that I had to stop all my cultural stuff because I had to focus on studying and we had to follow the Pālangi way, it was hard... group study added a little support as well as the cultural flavour that we needed. Studying with other Tongan students was quite fun because they would explain to each other in Tongan, because that's how they understood and you would be sitting there and you would go 'Oh my gosh, that's what that means' and because we had different strengths… we all had our strengths and everyone helped each other in that… that's the only reason why I passed, and I got through first-year, because of that support (Grace, KOTE).

Most KOTE participants described language issues during their science learning, particularly comprehension of scientific terms and learning a scientific language as non-native English speakers. Studying with other Tongan students helped:

Science is its own language especially with the jargon that science uses. We don't have many of those jargon words in Tongan, so it's hard if you are a Tongan, and you are trying to understand what ethane is because we don't [have a word]. It was hard, but… some concepts are better explained in Tongan to Tongans. I know when I was [first at uni], when I used to study with Tongans, we would end up teaching each other in Tongan because it was more understandable than teaching each other in English, because half the English words we didn't know the meaning. To know science, you must know English, and English is not our first language, so it's a double burden on us (Grace, KOTE).

Using the Tongan language to translate science content was also helpful for ANZE participants:

I remember my friend used to word things in Tongan that [helped] me… He used to explain it using Tongan for me, it made me understand it more because matching up the [science] words to English doesn't have that same meaning… when I get muddled up, it's easier to use Tongan (Fifita, ANZE).

The benefits of collaborative peer academic support indicate that higher education should actively engage in small-group learning. It is evident from the stories outlined above that working with peers benefits university-level Tongan science learners. Encouraging or demonstrating the use of study groups early in higher education science programmes could help to improve the retention of those students who otherwise leave because of academic

and social disengagement (Tinto, 1993), particularly Pasifika (and other minority groups) who generally enjoy working collaboratively.

Acknowledging Tongan cultural values and practices

A central aim of this research was to determine how Tongan cultural values and knowledge are acknowledged by the University, especially how relationships are constructed between Tongan students and their teaching staff or their peers. When considering engagement, enjoyment, and success, it is equally important to understand how Tongan cultural values and knowledge may be in conflict with the institutional system and create tensions for Tongan science learners. Previous research has argued it is essential that the values and ways of creating meaning of non-mainstream groups are respected (Anae et al., 2001). Acknowledging and examining these values allows the opportunity to explore different educational philosophies that may complement the dominant western paradigm and encourages the provision of relevant Pasifika learning contexts. The following stories outline the participants' thoughts about the place of *faka'apa'apa* at university, the discussion of tapu course content, and the conflict presented by learning WMSK and believing in God.

Faka'apa'apa.

With respect to the expression of cultural values, both groups recognised the place of *faka'apa'apa* (respect): most KOTE participants felt the University's learning environment lacks respectful relationships that acknowledge hierarchy; some ANZE participants wanted interactions that demonstrated mutual respect rather than that typical of the traditional Tongan hierarchy. These positions reflect the participants' differential exposure to Tongan cultural values and knowledge, at the very least because of their experiences of different educational contexts.

Engaging with teaching staff was complicated by *faka'apa'apa*. *Faka'apa'apa* heavily influences how relationships are enacted within the *vā* and determines how the social group functions, with a focus on maintaining the collective rather than the individual. *Vā*, or the space where relationships or interactions occur, is a viewpoint found in many Pacific countries including Tonga, Samoa, and Fiji. As the relational space, *vā* recognises the 'socio-spatial' connection and the importance of balance in relationships (Airini et al., 2010). Unlike western conceptualisations that consider space as something to be filled, the *vā* is never an

empty space. Instead, the *vā* is filled with the relationship that exists between two people, groups, or entities; there is always some relationship, whether it is positive or negative, supportive or derogatory, and those involved both have responsibility for how the relationship works (Ka'ili, 2005; Fa'avae, 2019; Thaman, 2008). *Faka'apa'apa* can give a framework for positive interaction as it "begins with an individual giving, sharing, considering and listening to the other; [faka'apa'apa] is fundamentally about honouring and protecting the dignity of the other" which ultimately means that *faka'apa'apa* will be returned (Fua, 2007, p. 676).

Both KOTE and ANZE participants avoided communicating because of respect for authority and not wanting to seem impertinent. The tension between respect and seeking advice was further complicated by the emphasis placed on questioning and critiquing in science education, which requires "the development of higher-order analytical and critical-thinking skills to produce meaningful hypotheses and to be able to articulate science-reasoning abilities" (Cundell & Pierce, 2009, p. 33). This questioning often contradicts the values by which many of the participants were raised:

> *I have grown up not to question things… [but] in science you are meant to question everything, to ask questions in class. A lot of Tongans feel that we don't want to annoy anyone… we are more the type to be passive, accept what is told to us, because we don't like to make a fuss… [In] the classroom you don't want to hassle the teacher, so you take it in. That makes it a lot harder in sciences because in science, they always push students to think deeper and question what they hear, so faka'apa'apa goes against it… (Lupe, ANZE).*

ANZE participants were less likely to discuss *faka'apa'apa* in terms of managing relationships with teaching staff. When they spoke about *faka'apa'apa* and respect, they felt it should be mutual rather than hierarchical:

> *The Tongan [way] is always respect your elders and that's fine. [But] it should be both ways, not only a one-way street where I will always respect you. I would say faka'apa'apa both ways… I would say there is room to communicate, to share each other's' ideas, it doesn't have to be a top-down approach, you can incorporate both, so faka'apa'apa and tauhi vā with anyone (Kalala, ANZE).*

This perspective may demonstrate the exposure of the ANZE participants to mainstream Aotearoa New Zealand culture, mainly how it has influenced their ideas around hierarchy and equality, which are different from those of the KOTE participants.

The KOTE participants often compared the embodiment of *faka'apa'apa*/respect; they considered it more 'obvious' in Tonga and often absent in Aotearoa New Zealand classrooms. For example,

> *Respect is a very big part of things, in my church, in my family, there is always a hierarchy …It's seen as good thing, knowing where you are, what's your role… [At university] with respect, students would get up when the time's up. That is so rude. The lecturers understand why, but… that's not right, I see it differently ('Ana, KOTE).*

The University aspires to reflect its position in the Pacific region and provide inclusive teaching that supports a diverse student cohort (University of Auckland, 2012). However, several participants were adamant that the University could not include values and practices from non-mainstream cultures, even though acknowledging aspects such as *faka'apa'apa* would make the education system more culturally appropriate for them:

> *The educational system, especially the tertiary level, doesn't cater to our cultures so if you bring something in that is more cultural, like the Tongan values, it wouldn't work, because it's more a westernised environment, the structure of the system… When you are home, then you can be respectful. I feel I shouldn't question, even if I have strong opinions. I must dampen it down and go with [it]… be a little bit more respectful to the teachers. That was a huge thing, going to school in Tonga, growing up in Tonga. When I moved here, the first few months, it was weird, I was like 'What is this? These are Tongan students, and this is how they are to the teachers?' I felt it was rude… (Mata, KOTE).*

Course content & gender relationships.

Building on concerns raised around the teaching of *tapu* content and gender (see Chapter Six), several female participants described how course content and its delivery in the learning environment conflicted with cultural values such as *faka'apa'apa*. *Faka'apa'apa* is more than respect in relationships: "*faka'apa'apa is such a big thing in Tongan culture because it doesn't have to be relations between a specific person and another, it affects different things* (*Setaita, KOTE)".* A common concern was encouraging students to study together in cross-gender groups, especially if topics are *tapu* (sacred, out-of-bounds):

> *Gender plays a big part in study groups because of faka'apa'apa between boys and girls, especially on the topic of reproduction. [In science], you can't talk about sexual organs or STDs, you can't talk about it because in Tongan culture its embedded into us that that stuff is meant to be separate, its tapu. In terms of in physics or chemistry it's all good, but when it comes to [reproduction etc.] it's hard… it limits Tongans from learning off each other. It's one thing to keep the faka'apa'apa between the girls and the boys but it's also another thing to help each other… but you must be aware… so it restricts us, especially in class… (Grace, KOTE).*

Although group work is positioned as an effective teaching approach for Pasifika students it is a more complicated situation than assuming all Pasifika students prefer to work collectively. Several participants suggested that the male/female dynamic influences student classroom discussions, with females less likely to talk. The research participants who raised this issue indicated that this dynamic was exacerbated if the males were Tongan, although other unspecified cultural groups were known to have similar concerns. Although at university students should be able to expect that teaching staff acknowledge the sensitivity of particular topics as an ethical expectation (Murray, Gillese, Lennon, Mercer & Robinson, 1996), this was not the case for reproductive content either as a point of discussion or as visual imagery:

> *The (lecturers) don't give us a warning, you will walk into class and bam! All you can do is look down, and write, don't make eye contact with anyone, and… it would be nice to acknowledge because I know it's not just Tongan culture it's other cultures (Grace, KOTE).*

Instead of showing explicit images, the participants suggested teaching staff could use diagrams as this made them more comfortable with the content:

> *In med school, they don't show photos of…. [pause] see I am finding it hard to talk about it… it's a cultural thing, we don't even talk about things like that… they would give us diagrammatic ones, not the actual ones, that's good ('Ana, KOTE).*

Explaining the inclusion of sensitive topics can also help explain the necessity of including such content, while forewarning students about sensitive content, for example, before showing graphic images, can help to minimise their distress and discomfort (Fonua, 2018).

Faith and spirituality.

The participants often felt isolated by their religious beliefs, particularly the KOTE participants, impacting on how they expressed themselves:

> *…the cultural differences. I [feel] Tongans are super different [about] how they interact with each other. At university, which is predominantly Kiwis, there is going to be a clash… their values are different… for me, faith is a huge part of my Tongan culture. I am not able to express how I think or feel about things because of my fear that everyone is so secular that you can't do that ('Ana, KOTE).*

There is relatively little research examining the impact of religious belief on sense of belonging in science in higher education, even less regarding Tongan or Pasifika students' experiences. Fraser (2007) described the nexus where school teachers' professional and private lives meet regarding their spirituality and their teaching role. For the Tongan students in this research, they are negotiating a similar nexus, albeit religious belief rather than spirituality, but with the added complication of being a minority ethnicity in the cohort.

A notable example of this nexus is the topic of evolution. Evolution is considered to be one of the main theoretical frameworks in biology, with some arguing that to be socially scientifically literate, it is vital to understand and apply evolutionary concepts (Brownell & Barnes, 2016). Nonetheless, for most participants in this research, the course content relating to the theory of evolution created value conflicts with their faith or religious beliefs. The way religion and evolution are discussed together in class is influenced by the personal beliefs and religious worldview of teaching staff, particularly if they consider religion and evolution incompatible (Bronwell & Barnes, 2016).

Many participants raised the delivery of evolutionary theory in their science classes as an issue and then provided insight as to their different coping strategies. For example,

> *Jake: …that is a big thing that I have thought about since high school, I always try not to make them mix. I try not to bring my religion into something that I am learning because it mixes things up. I do find it conflicts… there have been lectures where they have asked, 'Put your hand up if you believe in evolution', and… the whole class puts their hand up, and then they ask, 'Put your hand up if you believe in Creationism' and there is a few of us. I remember one time I put my hand up for both and [the lecturer] asked, 'What are you doing?' and I said, 'I believe in both' and he left it at that. But sometimes I have that problem with my faith and my religion compared to what I am learning*

SF: Do you feel that you must hide your religion?

Jake: Yeah, in a sense where most lecturers are like, this is medicine, its factual stuff, there is no time for beliefs.

Teachers can have deficit perspectives regarding students with religious beliefs, particularly in science (Novis-Deutsch & Lifshitz, 2016), and if they consider evolution and religion incompatible (Brownwell & Barnes, 2016). Various aspects can address this type of value conflicts: teachers use 'value-neutral teaching' to avoid contentious topics; teaching staff openly discuss values to encourage the sharing of experience and perspective; and thirdly, teachers change the curriculum to avoid or adapt contentious topics (Novis-Deutsch & Lifshitz, 2016). Recent research indicates that open discussions about religion help the understanding of evolution and encourage positive views of science, especially if students' beliefs are acknowledged by teaching staff who also discuss how religion and evolution can be compatible (Brownwell & Barnes, 2016). However, the previous narrative demonstrates how using an open discussion approach can make minority students feel isolated in their learning environment and how unsafe some of these teaching practices are for the students who experience them, suggesting any open discussion around religious beliefs and evolution needs to be well thought out and value-neutral, especially if the teaching staff consider them incompatible concepts.

Student lives

Previous research has highlighted the influence of family on Pasifika tertiary education success (for example, Anae et al., 2002). Nevertheless, the participants often felt the organisational culture of the University did not recognise the importance of family for them. The participants suggested tangible ways to acknowledge and include family, for example:

Having your family there to support you throughout uni [is important]. Maybe if there was a programme for parents to understand what uni life is about? Especially for my parents who didn't go to uni, they think high school is the same as uni, that going to class is enough, but at uni there are other things you must do (Soana, KOTE).

If universities are serious about improving Pasifika success acknowledging the significance of family would assist this. For example, recognising the significance of relationships outside of the immediate family for different administrative processes:

> *When there is a family issue, it could be your mum's cousin who I would call my aunty, but when you apply for compassionate [consideration] the University would say, 'Oh, this is a distant relative', even your grandparents [aren't] your immediate family, but that grandparent raised you! Those values are a lot different, it is important to attend their funerals (Lupe, ANZE).*

Although the University's process is fairly flexible, the participants (and seemingly some staff) were under the impression it was a set definition. This suggests there is inadequate dissemination of information that is particularly pertinent for Pasifika students managing pastoral issues.

According to Conrad, Canetto, Macphee and Farro (2009), high achieving socially disadvantaged students are attracted to science for a variety of reasons including their scientific curiosity and passion, the relevance for their communities, future employment and their enjoyment of the subject. This research's participants had similar reasons but also identified the importance of personal motivating factors, the element of 'self.

Tait, Horsley, and Tait's (2016) study of high achieving Pasifika students found that strong personal beliefs, beliefs about their ability and persistence contributed to their success, alongside the usual social influences. For the KOTE participants, this personal element was evident; narratives often highlighted their self-belief as well as a definite career goal, alongside the influence of family:

> *I wanted to become a doctor. I knew I had to study this, and I would often study hard and get good grades… that's probably what helped with my enjoyment. I don't think it's anything that's helped me stay in science… it's me, not my learning, but more the passion, and always thinking about why I am studying, the people, my family, the reasons behind (Mata, KOTE).*

Many researchers have demonstrated that having clear goals is strongly linked to academic success (for example, Madjar, McKinley, Jensen & Van Der Merwe, 2010). What is interesting to remember here is that twenty of the twenty-six participants completed a foundation/bridging programme before starting their science-focused degrees at university. This situation suggests that given the opportunity to experience science in a different teaching and learning environment, such as that provided by some of the University's

foundation/bridging[48] programmes, more Tongan (or Pasifika) students could potentially achieve greater academic success at university.

Managing Pastoral issues.

The complexity of the participants' lives requires them to constantly demonstrate their motivation and perseverance to be academically successful at university. Most participants had been managing serious pastoral issues or situations, such as coping with the illness and subsequent death of close relatives. These pastoral issues often affected academic progress and success, usually resulting in academic failure of some form, either of individual courses or preventing entry into specific pathways.

It is important to acknowledge here that every single case of academic failure amongst the participants could be linked to severe illness or death rather than a lack of academic ability. This is a significant issue to be aware of when considering Pasifika academic performance:

> *What hindered my success is not to do with academic stuff, it is personal stuff, family stuff. I lost my grandma and grandpa [over] three years during med school… they were the ones who raised me. I understand everyone goes through loss, but for me, that was a hard hit, and I didn't know how to manage it. I didn't know how to compartmentalise my emotional life and my academic, I couldn't find a way to balance… [so] I internalised it, I didn't seek help… I failed a year ('Ana, KOTE).*

> *In first-year it was full-on, I had many family problems … I was living in hospital pretty much for the whole time. I had three deaths as well, the first time I had had close family pass away, that was hard. Nobody knew what I was going through to be honest, I am not one to share, so nobody knew what was happening in my life. People knew I was going to the hospital, but they thought I was just visiting, they didn't realise I was living there... my living situation hindered everything (Avila, ANZE).*

Losing family members had severe consequences for their engagement as students. Avila took a year off and then returned to complete her degree. These stories highlight the necessity of understanding a student's life outside of the classroom, thus enabling educators to support their students as well as acknowledge the level of everyday responsibility some participants shouldered, especially when providing care for family members.

[48] 'Foundation education' refers to certificate programmes at NZQA Levels 1-3; 'bridging education' refers to programmes ranked as NZQA Level 4 and higher (Trewartha, 2006).

Young carers are defined as people under 25 years of age who are "providing significant care for persons who have a disability, illness, or whom are elderly" (Hitchin, 2013, p. 5). Some studies suggest that between four and ten percent of children and young people have significant responsibility for the care for a family member or friend, usually with whom they live. Often, they are the primary carer, providing substantial amounts of care and assuming substantial personal responsibility (Moore, McArthur & Morrow, 2009). In this research some participants were very involved in the care of family members managing chronic illnesses: *"my grandparents live with us, one has type 2 diabetes and my role is to look after [them] and give [their] insulin injections, the other one has blood pressure, so I have minor responsibilities like that (Mata, KOTE)".* Mata assumed this role when she began her medical degree, requiring her to balance her 'young carer' responsibilities with her studies:

> *I started looking after [my grandparents], in terms of their health, after starting to study medicine. It's been put on me which in a way is good practice for me, but at other times I need to study… [My family] give me as much study space as they can, but my grandmother has type 2 diabetes… I have to get up every morning because I like to do her insulin, and there is a particular time in the afternoon… it doesn't take up my study time… [the injection] is at 12pm, so I have to stay back sometimes to do it before I go because my class starts at 1pm, so I do it before I go. I study at home before then, then [inject] her, before I go. It's always [my priority]… My grandmother can do it by herself, but …I think having someone else do it is much better. My parents never force me to miss class but, if my grandmother does it, when you check her sugar level it's not getting better. For me, I need to do it myself (Mata, KOTE).*

Caring for others has both positive and negative impacts. Mata sees benefits for helping her grandparents; it is essential to her that she cares for her grandparents to ensure they are receiving proper treatment as well as the practice and experience this provides her for when she becomes a doctor. The negative side of being a young carer can include significant impacts on education, particularly engagement, attendance, achievement.

Unfortunately, the participants often felt failure was expected of Tongan science learners, based on assumptions about their academic ability, rather than the reality of their lives. For example, *…it's also hard, because I am repeating [a year of medicine], when I say I am repeating to someone they would assume that [I] am dumb, rather than because it was a family issue (Lupe, ANZE).*

Most of the affected participants did not engage with any support services at university. They usually felt they should deal with it themselves, and it was their fault they did not achieve. For example, discussing how a participant deal with a significant pastoral situation that affected them during the competitive Year One programme,

> *SF: Did you get any help?*
>
> *Takai: No, not really …No, I mean I didn't get in [to medicine], that's all on me so that's my fault so... that's what I think, it's all on me, so why should I bother anyone else? I am the one who gets the grades so if I don't get the grades…*

When Takai did not achieve entry into medicine, he blamed himself, rather than considering how his pastoral situation had affected him academically. It is essential to consider how many Tongan students have not succeeded academically at University, not because they do not have the capability, but because they have not had access to the appropriate support. And given the likelihood of Tongan and other Pasifika students living with extended family or within large families it is also necessary to consider how often they play the role of 'young carer' and how this is supported in their academic journey.

Implications for Science Teaching

Although some suggest that positivism's grip on science has waned slightly since the mid-twentieth century, others argue that linguistically it is still well entrenched and that the positivist position continues to dominate the "current orthodoxy within scientific communities" (Edwards, O'Mahoney & Vincent, 2014, p. 7). Since beginning this critical self-reflection, I have wondered how many other science educators have considered the influence that positivism has on them? Additionally, how has the empirical and reductionist approach of their formal science education informed their understanding of science? And how has their ontological and epistemological positioning influenced their approach to science education? Could this be a contributing factor to why Tongan and other Pacific students are not achieving in science akin to other ethnicities? If various government policies and initiatives have not achieved an improvement in Pacific student achievement over the last few decades, perhaps it is because they have not required educators[49] to consider a shift in their ontological position. I raise such questions about ontology here because of the

[49] This is a particular concern for university-level science where those employed to teach are more often than not trained scientists rather than trained teachers.

centrality of ontology to critical realism, and this reflective process has revealed how my ontological position has influenced my teaching and learning approaches over time.

The challenges critical realism applies to positivism are critical considerations for science educators to be exposed to, to reflect on, and to debate. If positivism dominates science, then it follows that most science educators, particularly those at university, have been exposed to a positivist ontology throughout their education, employment, and academic pursuits. As such, they will have usually spent their lives focusing on a "'flat actualism' that does not probe underlying structures and causal mechanisms that may be beyond perception" (Tikly, 2015, p. 243). In contrast, critical realists consider how the social world is shaped by the intransitive dimension, that consisting of deeper causal mechanisms and structures such as social inequity (Tikly, 2015). These invisible, yet influential forces, including the cultural, political, economic drivers present, can affect what is considered normal, usual, and valued, and ultimately, what is real and how knowing is enabled (Gorski, 2013). For the most part, university science educators are employed for their research capabilities rather than their teaching experience. As a result, reflecting on how forces contribute to a social situation, such as why some students are not achieving in their course, are not usually part of these educators' focus, interest, or consideration. Instead, these outcomes in the form of marks or grades are an empirical, quantifiable result that they may or may not have to justify or explain.

I suggest that critical realism's stratified ontology is useful for such considerations. In particular, how to consider the three realms to critique how science educators engage Pacific students. Sharar (2016) provides a useful analogy[50] to understand the domains by explaining how a student's potential could be known in each realm: the student and all their potential exist in the real domain; in the actual realm exists only the abilities that the student has been able to realise in a particular situation or context; whereas in the empirical realm what is detected is the evidence of the student's potential. If a science educator only considers the learner's results in their class, they can assume that that demonstrates their true potential, rather than representation in the empirical realm. For example, a Tongan student may have an exceptional talent for sciences (the real realm). Yet, if science subjects are not available at

[50] This analogy has been tweaked slightly to fit the science focus of this research. Sharar's (2016) original example related to mathematics.

secondary school or they are not able to take science (the actual realm) because of streaming or a lack of resources, their university grades may not be high, thus giving the impression that they are not academically able (empirical realm). If we do not consider the possibility of the actual and real realms, then this could easily lead to a stereotyping of learners based on observed patterns (i.e., grades, behaviour) rather than an understanding of the causal mechanisms in the real and actual domains that have led to this expression in the empirical realm; the idea that Pacific achievement in science is lower than other students because they are not good at science. Instead, a stratified ontology can counter such false universalisms by insisting on considering a deeper reality. For example, acknowledging that success (or failure) is not just the result of the individual learner's actions, but complicated by causal mechanisms such as social inequities that are operating at multiple levels.

It may be worth using one example here to demonstrate engagement with critical reflection and concepts such as agency: the often-expressed lament that Pacific students always sit at the back of the lecture theatre. This empirical observation of Pacific student location[51] can reinforce stereotypes about negative academic outcomes. A critical realist would ask why these students sit there in the first place; this leads to the consideration that because of educational inequities in society (real) there are very few Pacific students in a university lecture theatre (actual), so sitting together at the back (empirical) can feel 'safer'. When this ontological position is taken, it demands a shift in how this situation is considered and exposes the power dynamics at play. This view highlights the agency of educators and their responsibility to make Pacific students feel welcome by venturing out of their safe space at the front of the lecture theatre, to actively engage with students who mighty prefer to sit at the back for a multitude of reasons. It also acknowledges that within the visible and invisible structures of a university, the educators (i.e., lecturers, tutors, lab demonstrators, etc.) have agency in this situation, not the students. Furthermore, there is only so much space at the front of the room, and is that where educators would like them to sit within the physical structure these students find themselves? Unless these types of causal mechanisms are considered and addressed by those with agency (i.e., educators), the potential for ongoing consequences, which include limited educational trajectory, future employment, and

[51] This oversimplified explanation does not extend to other issues such, as the incorrect belief that ethnicity is visibility which is beyond the scope of this thesis.

active citizenship in Pacific communities, remain as critical issues in the science education of Pacific learners.

Concluding comments

These stories contribute to the understanding of Tongan science learner experiences in the University's science learning environment. Overall, they present a picture of the benefits but also the challenges of learning science at the University. Institutional culture and support affect student engagement in higher education, particularly for non-traditional or minority students. Students need to feel part of the learning community; they need to feel connected to the institution they attend. It is the minority student's sense of belonging to the institutional culture, the mutual relationship between how the student interacts with the institution and the teachers that will inform their success (Johnson et al., 2007). Nevertheless, minority students usually have less sense of belonging than mainstream students, a position influenced by negative interactions within the student cohort and with staff, the academic curriculum, microaggressions, and experiences of racism. Therefore, it is necessary for the University to understand that its desire to create an environment that acknowledges diversity and provides inclusive teaching as per the Strategic Plan 2013-2020, does not necessarily translate to the type of learning environment that these Tongan science learners experienced.

Chapter Nine - Science learner identity: conception of self and taking science

Identity is a complex concept that covers many aspects of a person, such as who they are and their sense of belonging. Identity is formed by "an ongoing process of negotiation within multifaceted structural and agentic relationships" (Wong, 2015, p. 981). In other words, identity is socially constructed and continually informed and shaped by interactions with people (i.e., agents) and structures such as educational institutions. How students are taught, and the expectations placed on them, are often determined by identity (Lee & Anderson, 2009). Identities are formed by what students bring with them to the classroom and what the classroom, school, and educational contexts suggest to them about their academic ability, teacher expectations, and their academic potential (Samu, 2015). Identity formation involves multiple players, including the "important interpersonal relationships in the context of institutional structures", such as those between teachers and their students (Syed, Azmitia & Cooper, 2011, p. 443). Therefore, how teachers and peers engage with minority science learners becomes a key determinant in the formation of a student's science learner identity. These interactions can also maintain academic inequities, particularly as the micro-interactions in the classroom between teacher and student often reflect and reinforce the power relationships and perspectives of the macro-interactions within wider society (Cummins, 1997).

Practice theory examines the relationship between 'meaning systems' generated by participating in everyday activities and the broader patterns of social reproduction that maintain inequalities. Cultural production or "meanings developed by groups in their everyday activities", is a form of practice theory that provides an interpretative framework to understand classroom culture (Eisenhart & Finkel, 1998, p. 44). It emphasises the importance of the learning setting and how the classroom's context and social organisation reflects local meanings, such as who is a 'good' science student. These local meanings influence identity formation, informed by more extensive socio-historical processes that affect a student's beliefs, values, and actions, further validated by the behaviour of teaching staff and peers (Carlone, 2003; 2004).

Considerable research (e.g., Nadal et al., 2011; Steele & Aronson, 1995; Sue et al., 2007) indicates that most ethnic minority students will experience negative verbal and non-verbal interactions during their education. This research is no exception. For the participants, this negativity came primarily from their peers and teaching staff. It focused on them as Tongan (or Pasifika) science learners, being the 'only brown person' in their science classes, and Tongan (or Pasifika) science learner achievement in Aotearoa New Zealand. These interactions impacted on how the participants experienced their science education and themselves as science learners. Therefore, for this study, it was essential to consider the importance of science learner identity. This chapter is positioned after their stories of the secondary and university sectors because these experiences provided insight into how their science identity has been constructed and influenced by their sociocultural selves and their education .

Science learner identity

Learner identity has become increasingly important in science education to understand why students take science or pursue a career in science. Science learner identity has three overlapping dimensions: 'competence' demonstrated through 'performance' that requires the 'recognition' of significant others, such as educators and peers (Carlone & Johnson, 2007). Forming learner identities while in the education system means a student's "performance, participation patterns, and expectations become patterned and habitual" (Carlone & Johnson, 2007, p. 1191). Practice theory has been used to demonstrate how sociohistorical legacies of science and science education are maintained and contested by school science and the everyday practices in a science classroom, by considering how everyday activities make knowledge and learner identity socially available and reflect power dynamics (Eisenhart & Finkel, 1998; Carlone, 2003).

Key to learner identity is self- efficacy, an individual's beliefs about their ability and their environments. Four sources inform self-efficacy: (1) mastery experience or past performance, which in turn informs (2) resilience; vicarious experience or comparisons with others; (3) social persuasion or judgements of others; and (4) physiological or emotional states. How an individual integrates this information will determine their performance under varying circumstances (Bandura, 1997). In science, self-efficacy plays a significant role in

determining success; therefore, attempts to increase achievement and engagement in science must focus on self-efficacy (Britner & Pajares, 2006). There is a positive association between self-efficacy and academic outcomes (Britner, 2002), as resilience (Bandura, 1997) and motivation and commitment (Lau & Roeser, 2002) can be very influential on achievement. For example, many participants in this research felt that at secondary school, Pasifika students were not considered to be good at science and discouraged from taking it:

> *I think the school expected them to do [non-science subjects]… It seems they only expect brown boys for rugby…or they feel obligated to do it sometimes. If you are Tongan here, you must be good at sports, or drawing or singing… None [of my friends] did science, and most of them dropped out after fifth form or sixth form… there were not enough expectations from the school. If you skipped class, they were like, 'Oh, that's what they do…' (Naua, KOTE).*

Ethnic minority students often feel isolated and out of place in their learning environments because they are underrepresented, and because of the stereotyped perceptions of their educators and peers (Syed et al., 2011). Stereotypes can affect how students identify with their learning environment and impact on their achievement. Known as 'stereotype threat', this is a "social-psychological predicament that can arise from widely-known negative stereotypes about one's group" (Steele & Aronson, 1995, p. 797). Internalising the stereotype can disrupt achievement; it becomes a 'self-threat' that can impair academic performance confirming its plausibility to others and oneself. Another form of stereotyping is racial microaggressions, "subtle statements and behaviors that unconsciously communicate denigrating messages to people of color" (Nadal et al., 2011, p. 470). Sue et al. (2007) identified three forms: 'microassaults' or verbal or non-verbal actions that are explicitly derogatory; 'microinsults' which are communications that subtly denigrate racial heritage or identity; and 'microinvalidations' or interactions that "negate, or nullify the psychological thoughts, feelings, or experiential reality of a person of color" (Sue et al., 2007, p. 278). Although all microaggressions can affect self-esteem, those that occur in the educational context are more detrimental to self-belief (Nadal, Wong, Griffin, Davidoff & Sriken, 2014).

Secondary school science learner identity.

To address Pasifika underachievement requires the recognition of heterogeneous identities and realities of Pasifika students (Samu, 2015), as well as the diverse academic identities of Pasifika. Therefore, to acknowledge that their experiences of different educational contexts have produced different academic identities, in this section, the KOTE and ANZE participants' stories are separate. This research is not intending to provide a commentary on Tongan identity relative to nationality or ethnicity. Instead, this section recounts interactions that have impacted on successful Tongan science learners' self-perceptions and science learner identity, thus providing a contextualised understanding of the realities of these Pasifika learners.

KOTE participants.

Unsurprisingly, families moved from Tonga to Aotearoa New Zealand, mainly for education: "*the whole point of us moving to New Zealand [was] to get a good education and get a good future for us*" *(Setaita, KOTE).* Nevertheless, the KOTE participants perceived a distinctly 'weak' or negative science learner identity for most Tongan or Pasifika students in Aotearoa New Zealand. This identity contradicted the strong science learner identity most had formed in Tongan schools where Pasifika taking science is a good thing, normalised or expected; whereas in Aotearoa New Zealand, Pasifika students taking science is 'odd', unusual or discouraged (i.e., for Pasifika students within the schools they attended in Aotearoa New Zealand). . Although school dependent, most KOTE participants[52] were encouraged to take secondary school sciences in Tonga regardless of school type, unlike many ANZE participants. The KOTE participants often described encountering a negative Pasifika science learner identity in Aotearoa New Zealand.

Immigrants often compare their living conditions and access to opportunities to those of their peers and family in their home country. In general, this comparison, or dual frame of reference, will demonstrate the positive changes and wealth of opportunities they have gained by moving, often influencing their adaptive strategies to educational opportunities as they "adopt the folk theory of success of the dominant group" (Ogbu, 1987, p. 328). All KOTE

[52] This is referring to KOTE participants who did some or all their secondary schooling in Tonga. Some KOTE participants shifted earlier and experienced all their secondary science education in Aotearoa New Zealand.

participants migrated for educational opportunities, yet often those who shifted when they were older described intensely negative perceptions of Tongan/Pasifika students in Aotearoa New Zealand:

> *…when you get to New Zealand, and you hear all these things in the news, you… start internalising it. You start thinking that you are also dumb, you aren't going to make anything of yourself… there is such negativity to Pacific Islanders, including Tongans, about education, they think we are not as smart… all those negative connotations, not doing well in education, being dumb and going to do labouring jobs. I feel I must prove myself because I am Tongan, that any Tongan or Pacific Islander can do it (Mele, KOTE)*

Disappointingly, we can consider perspectives shared by other Tongans, such as Lita Foliaki, a Tongan educator, who moved from Tonga to senior secondary schooling in Aotearoa New Zealand in the 1970s. These comparisons suggest little has changed in more than forty years:

> I became very confused, then I began to feel very dumb. I believed that the other students perceived me as dumb, and maybe they did. Unfortunately, I think the teachers may have thought I was dumb too. When one is the only non-white person in the classroom and one is the "dumbest" in the class, one begins to think that the two factors are connected. There are probably very few schools in Auckland today with only one Polynesian student in the class, but I think the only difference is that instead of one Pacific Islands student at the bottom of the class, there is now a group of Pacific Islands students at the bottom of the class, thinking the same thing that I did (how many years ago?) (Foliaki, 1992)

When a student moves into an established learning community, they must negotiate their new position or 'positional identity' in their new community (Holland & Lave, 2001). For most KOTE participants, the deficit expectations of their Aotearoa New Zealand secondary school community regarding Pasifika students and science eroded their self-efficacy. Their previous beliefs, their 'narrated' learner identity, was overshadowed by comparisons with others and the messages they received about their ability in sports; their vicarious experiences and social persuasion contributed to the formation of a new 'embodied' science learner identity. This new learner identity did not reflect their original ability or career focus; it often resulted in them negatively responding to stereotype threat and not achieving university entrance[53].

[53] Mele gained UE by completing a foundation programme.

This story demonstrates how pervasive, influential, and detrimental the deficit perspective of Pasifika learners taking science is in Aotearoa New Zealand.

Ogbu (1987) found that immigrant students did better because they assumed the success of the dominant group in their new home. However, this research indicates that encounters with a Pasifika underachievement discourse complicated the KOTE participants' experiences. These culturally produced local meanings of Pasifika underachievement were not common knowledge in Tonga:

> *…when I go back to Tonga and I tell them all this stuff, like I am the only one that passed… when I tell other people in Tonga, they say 'Wow, I didn't know it was like that'. When I first started school here, because I was the only one there, I started hearing stories about Tongans, people who are my age that don't do well, there are also those negative [comments]… and hearing that, that made me think, 'Oh my god, is that true?' I didn't know we were that bad here in New Zealand (Setaita, KOTE).*

The strong academic performances that all KOTE participants demonstrated in Tonga often changed when they moved, especially for the younger migrants. Earlier migration resulted in more prolonged exposure to local meanings of achievement, increasing the impact of their new setting and its socio-historical practices on their adaptive strategies, often negatively influencing their learner identity. For example,

> *I would get good marks in Tonga, that's why that my science [is good]. I went to a Pālangi school here. I was the only Tongan to do science, some of the teachers were so surprised I did science, I think they expected me to do arts and stuff, but I didn't… [when] the teachers asked me what I want to do, I told them I want to be a doctor, I want to do science, and [they said] 'Oh, you don't you want to do arts? I [had] never done arts in my life! (Fatai, KOTE).*

Fatai migrated early in his secondary schooling. He found it challenging to navigate the expectations of his school, particularly regarding sport:

> *Science [was] one of my strongest points, but… sports took over because everyone [thinks] 'He's Tongan, he must be good at rugby'. Instead of putting all that time in studying, I used that time to go training and socialising with the rugby boys, trying to fit in, to earn their respect pretty much. Rugby and other sports got me at Year 13, and then it was ahhh [indicates downhill].*

When considering science education, Tan, Calabrese Barton, Kang and O'Neill (2013) suggested "narrated identities-in-practice is telling how one views oneself in specific contexts, embodied identities-in-practice is performing who one is in specific contexts through one's actions and relationships with discourse, tools and resources within social contexts" (p. 1148). If these two identities are complementary for ethnic minority students, then interest in science will be sustained; if they conflict, then it will not. Most KOTE participants indicated that their science learner identity was affected by their shift to Aotearoa New Zealand. The longer they were in Aotearoa, the higher the impact on their self-efficacy, learner identity, and ultimately achievement; the earlier the migration to Aotearoa New Zealand, the more likely they were to renegotiate their learner identity and not achieve their original goal.

Migrants often feel inferior and are subjected to discrimination and prejudice; sometimes, teachers put migrant students with low-achieving students based on their perceptions and assumptions that they are 'slow' or behind in their achievement (Romanowski, 2001). For the KOTE participants, negative assumptions about the quality of the education in Tonga (see Chapter Six: Education in the Kingdom of Tonga) contradicted their experiences of teaching in Tonga:

> *For the first couple of years I was lost. I felt I was shunned for knowing my stuff because, in the Islands, the education system is quite hard and quite strict, it's very different to New Zealand… we had exams [often], we had to study, we had to compete with everybody, we had to try to be the best. Then I came here, and my sisters came here in primary school and I think they experienced the shock more because they [told me] 'All we did today was draw pictures and abstract thinking' whereas in the Islands we were told what was what and we had to learn and then sit exams (Grace, KOTE).*

Learning communities inform students of the community or classroom norms. In other words, they are exposed to "the ways of talking, knowing, doing and being" that determine different student identities, for example, how a good science student engages (Tan et al., 2013). These dynamics impact on the formation of the learner identity, the identity-in-practice, or in this case, the science learner identity. Identities-in-practice are influenced by the students' 'narrated' (i.e., how they speak) and 'embodied' (i.e., how they act) identities. In general, the KOTE participants were surprised by the Pasifika science learner identity in Aotearoa New Zealand secondary schools, particularly the negative perceptions of the

teachers, and attitudes of the students themselves. These views often directly contrasted their experiences of Tongan science education and the science learner identity they had formed in Tonga, which reflected strong narrated and embodied science identities.

For one KOTE participant, they had to convince their secondary school that they were seriously considering taking all three science subjects:

> *I remember when I picked my science subjects at school… the Dean had to call my mum to come in because they thought I was making a joke. I put all three sciences. I picked bio, chem, physics, calc, and English, and the Dean thought I was joking and rang my mum. My mum came in [laugh] and said, 'That's what he wants to do'. The Dean pulled out some stats about me having an 80% chance of failing, so I had to go talk to each [Head of Department] to see if they would consider [letting] me in the class (Naua, KOTE).*

For Naua, this experience contradicted their experiences in Tonga:

> *I had been here for a few months… and I was the only brown guy in the class. That was new for me, but it wasn't new for me [to take science] because in Tonga, everyone did science. When I came here, I was the only Pacific guy in the class, so it was a shock. It made me want to prove them wrong, you know, it made me want to prove it more, to show them I could do it. When I did well, they were all surprised. I topped biology and did pretty good in physics and chem as well, that didn't stop them though (Naua, KOTE).*

Students select subjects that they believe they are expected to take, particularly if they are on a lower 'track', a high proportion of whom are ethnic minorities (Yonezawa, Wells & Serna, 2002). Normalising a positive Pasifika science learner identity and a strong sense of self-efficacy, as in Tonga, might result in more Pasifika learners taking science.

ANZE participants.

Although identities are created within a specific context, history also influences that context and the student. The 'history-in-person' that individuals carry reflects "historical structures of privilege, rooted in class, race, gender, and other social divisions, as these are brought to the present" (Holland & Lave, 2001, p. 4). This concept acknowledges that inequities can be internalised and carried long-term. Many ANZE participants described a negative Pasifika science learner identity, advice not to take secondary science, and society's views on Pasifika students they experienced growing up in Aotearoa New Zealand. These views often impacted on their science identities:

> *You grow up, and you are told your whole life you are dumb, and then you get to university, and obviously, you are frowned upon because you're an Islander or a Māori studying science… you see more negatives than positives if you are studying science… at high school, when you tell people what subjects you are doing, and you tell them you are doing the Asian 5*[54] *and you are not Asian, they are… 'What the hell?', or 'Why?' or 'Ok?' (Avila, ANZE)*

Identity is important for the academic success and retention of all students but particularly so for under-represented ethnic minority students (Syed et al., 2011). Unfortunately, some teachers in Aotearoa New Zealand perceive Pasifika students through a deficit lens, which assumes their academic underachievement (Ferguson et al., 2008; Siope, 2010). These experiences can have long-term consequences for students and how they feel about taking science. One participant described the continued influence of her perception of their secondary school's attitude:

> *Because it was a white school, they didn't focus on Māori and Pacific students. They weren't very supportive or trying to push sciences …they were more concerned with their reputation. They didn't want people taking sciences and then fail[ing], so they were pushing people to take subjects they would do well. Even though that might not be good for them… I was scared that if I said anything, they would think I was dumb or not good enough. Sometimes I would think they are looking at me and thinking, 'Why is she doing sciences?' Even now, when people ask me what I do, I am too embarrassed to say I am doing medicine… I work at the hospital now [as a part-time job]. When the nurses ask me, 'Are you studying nursing?', I [say] 'No, I am doing med', they say, 'Oh… (Sina, ANZE)*

Changing learner experiences in science education requires acknowledging the influence of sociohistorical legacies in the school structure (Carlone, 2004). Pasifika students may have a long history of underachievement in the Aotearoa New Zealand secondary school system, but it is not equitable to consider this the default Pasifika learner identity, or that underachievement is caused by Pasifika students. Instead, the delivery of prototypical science education maintains narrow views of 'good' science students and 'good' science education (Carlone, 2004), in this instance, often to the exclusion of Pasifika learners.

Some of the ANZE participants' felt their understanding of their capability and their career goals helped them address the challenge of taking science:

[54] The youth slang term 'Asian 5' refers to Biology, Chemistry, Physics, Maths, and English. It makes a commentary on the perceived relationship between Asian students and science subjects.

> *I decided if I was going to go to uni, I would do my best to get into med school. I remember talking to my career advisor at school, and he told me to do something else because I probably wouldn't get into med school, which was pretty stink. But I am [almost finished med school], so it's all good… (Kava, ANZE).*

Other ANZE participants used this type of message to motivate themselves:

> *In Year 11, we were writing a report, and I didn't do well. The teacher said, 'You should probably reconsider taking science because I don't think you are cut out for it'. I was crying. I was upset… I went home and told my mum. She said, 'No, you are going to be a doctor'. I stuck with it, and that fuelled [me], because I wanted to prove her wrong, and I got top of the class for that year (Lashandra, ANZE).*

Pasifika students do not often get a chance to form their identities, "instead they are resigned to conforming to or rebelling against the identities that have been constructed for them" (Nakhid, 2003, p. 307). However, many ANZE participants did rebel against the imposed science learner identity and achieved, suggesting that their self-efficacy, resilience, and goal setting are essential factors in their success.

Being the 'only brown' student in class.

According to Bandura (1997), observing others, the judgements of others, and the individual's emotional state informs self-efficacy. Therefore, for many of the participants in this study, being the 'only brown person'[55] in the classroom and experiencing microaggressions had significant influence over the participants' science learner identities. Microaggressions are likely to happen in almost all interactions between different ethnicities and the 'perpetrators', who are often unaware of their behaviour (Sue et al., 2007). These interactions can trigger self-doubt, feelings of isolation, and inferiority as the narratives below attest. Again, the narratives have been presented separately to respect the different experiences and stories of the two participant groups.

KOTE participants.

If learner identity explains ''individual agency as well as societal structures that constrain individual possibilities'' (Brickhouse, 2000, p. 286), exploring stereotypical perceptions of Pasifika students in the Aotearoa New Zealand secondary school learning environment is

[55] This phrase was used repeatedly by the participants, so it was kept as a direct quote.

essential. Several KOTE participants strove to offset these stereotypes as they did not want to perpetuate or validate these labels*:*

> *…I was one of the only brown people, I did have this other brown person doing science but she… didn't take it seriously, so it was up to me… to take it seriously. Nobody took me seriously in class… I did have some knowledge to contribute, but nobody recognised it. If they were to ask a question when the teacher was busy, I would answer, but they wouldn't believe me. When they asked the teacher, they would say exactly what I said, but nobody would acknowledge that I have some knowledge of these things. I learned not to talk, which made me feel smaller and smaller (Mele, KOTE).*

The recognition of others gives science learner identity credibility (Carlone & Johnson, 2007). Unfortunately, the microinvalidation or repeated dismissal by their peers of their attempts to contribute nullified their knowledge in the science classroom, affecting their ability to demonstrate and further develop competency as science learners. In Tonga, Mele had been recognised as a very academically capable student by her teachers and peers and received academic awards. In Aotearoa New Zealand, her self-belief and academic achievement were affected by her experiences in the learning environment, arguably demonstrating the influence of stereotype threat. Initially, Mele felt responsible for combating the deficit image of Pasifika achievement. Nonetheless, the negative judgements of their teacher and peers have affected her self-efficacy and performance[56].

Other KOTE participants found the deficit messages motivated them to do better in their studies*:*

> *[Being the only Tongan/Pasifika was] a bit lonely, especially because I had come straight from Tonga, so, lonely not seeing other PI people. At the same time, it motivated me to prove myself, because I knew most of the other Islanders, including the Tongans, were doing PE… nothing against them, but it's a bit more of a challenge to test my mind and study science, maths… It was motivating in that way, trying to prove that anyone can do it, it's not an Asian, Indian, Pālangi thing. Even the brown ones or even the ones from the Islands can do something, get somewhere (Seitaita, KOTE).*

According to Bandura (1997), positive physiological states will promote positive performance. With specific reference to strong self-efficacy in science, Britner & Pajares (2006) have

[56] This is another KOTE participant who achieved university entrance by completing a university foundation programme.

argued that this means students are more likely to choose "tasks and activities, work hard to complete them successfully, persevere in the face of difficulty, and be guided by physiological indexes that promote confidence as they meet obstacles" (p. 486). Despite describing their isolation in the science learning environment, Seitaita demonstrated that such students exercise resilience by choosing to study science because it would challenge them. Her positive self-efficacy enabled her to ignore the negative discourse concerning 'brown' students and science, creating the possibility for her "to fully express their competencies, abilities, and skills" (Britner, 2002, p. 11), while at the same time seeing the opportunity to negate stereotypes about Tongans.

ANZE participants.

For the ANZE participants, being the ethnic minority in the science classroom negatively impacted their learner identity and self-efficacy, as they internalised deficit discourse and racial microaggression from their peers and some of their teachers. Unlike the KOTE participants, for most ANZE participants, these experiences were not motivating. Microinsults can make students feel excluded and isolated, causing them to question their learner identity and sense of place or belonging. For example,

> *I would joke that I am the only brown girl in class. [It seemed] that made it acceptable for them to mock me being the only brown girl in class. When I would interact with my friends who weren't in my science classes, they would say 'Oh, you are the white girl', it was weird because I didn't fit in either [group], that was hard (Lupe, ANZE).*

Internalising societal representations shapes understandings of who, or what, individuals can be (Grossman & Porche, 2013). Here, the perceptions of both types of 'perpetrators' were challenged concerning 'brown' students and science, causing them to try and reinforce what they knew about the power relationships and perspectives of wider society.

Student actions also reflect social identity (Brickhouse, Lowery & Schultz, 2000). Rather than celebrating Lupe as a Pasifika science learner, their peers considered it acceptable to put students like Lupe down, thereby replicating the power dynamics they have witnessed in society. Labelling the participant (i.e., Lupe) as 'white', is an expression of her friends' internalisation of societal representations. Such intra-ethnic harassment is a form of 'borderism', or the perception that an ethnoracial boundary has been crossed, triggering

verbal attacks that indicate the 'border crosser's' identity and loyalty are being questioned (Dalmage, 2000). Although limited, other research on 'acting white' suggests that these insults demonstrate the understanding of how non-white students should behave (for example, Simmons, 2012). By labelling them as 'white', the participant's friends are questioning their Tongan learner identity, suggesting that if they studied science they could not be 'brown' because Pasifika students do not take science. Previous research indicates that groups use borderism to maintain a positive identity and community in response to negative stereotypes (Smith & Jones, 2011). Concerningly, this narrative suggests the opposite; criticising Lupe is maintaining a negative science learner identity. To address Pasifika underachievement in science, we must determine where this 'understanding' of the Pasifika science learner identity originates. Being the 'only brown one' in their science classes often reinforced the ANZE participants' deficit perspectives gained from their social experiences which in turn, impacted on their engagement:

> *Sina: At school, I was the only brown one in all my classes for science… I had to get used to it. It wasn't that they were racist or anything, they were just different. I couldn't be myself, and I was too scared to ask questions or be involved at school…I was scared that they might think I am dumb.*
>
> *SF: Where does that come from?*
>
> *Sina: I guess it comes from wider society… you always think that white people are better because that's what been thrown at you. You think they are superior, and they know more than you. Because I went to a white school, all the teachers are white. You think anyone that's successful [is white].*

This narrative highlights the history-in-person of many Pasifika students in the Aotearoa New Zealand secondary school context. Stereotype threat and the belief that they are intellectually inferior as they are not 'white' hampers the formation of strong science learner identities. Internalising these messages often leads to feelings of exclusion and isolation or 'otherness' and can affect their academic performance (Nadal et al., 2014).

Previous research has found that minority ethnicities struggle to develop self-efficacy in inequitable contexts – contexts where they are not expected to succeed. Although Sina states that "*they weren't racist or anything*", she is likely to have experienced many microaggressions without recognising or acknowledging their impact because they are "so

pervasive and automatic in daily conversations and interactions [that] they are often dismissed and glossed over as being innocent and innocuous" (Sue et al., 2007, p. 273). Constant exposure to prejudice in the learning environment means students must develop resilience to continue their studies, otherwise even the most academically capable student will lose faith in their ability to perform in trying circumstances (Bandura, 1997). Fortunately, Sina had obvious career goals: "*lucky for me I knew what I wanted to do, I knew I had to take sciences, so I was determined by that*".

Another ANZE participant described receiving one of the top grades in their class and the microinsults that followed:

> *I was the only Pacific Islander in Year 13… it was hard. I would sit by myself. I can remember in my physics class, I sat by myself the whole year. We got one of our internals back, and in the class, one person had got excellent, one person got merit, and the rest of the class that passed all got achieved. I remember the teacher bringing round my assessment back, and he [said] congratulations on your merit… the guy in front of [said] 'You got merit?' and the girl behind me [said] 'Uou got merit? Congratulations' …I was disappointed with that because I knew when I got home my parents would [say] 'You just got merit, why is it not excellence?' [My peers] could see I was disappointed with that grade, and they said, 'How can you be disappointed with merit, you are an Islander doing physics!' At the time, I said 'Oh, thanks' but now… What's that meant to mean? What does that imply about Islanders taking science? (Lashandra, ANZE).*

According to Brophy (1981), teachers should be careful when using verbal praise because it does not necessarily reinforce good behaviour, especially if the recognition is infrequent, without credibility, complicated by nonverbal cues and context, and used by teachers for students for whom they have lower expectations. In Lashandra's story, praise has not reinforced achievement but instead triggered dialogue demonstrating deficit thinking towards Pasifika achievement in science. However, Lashandra's strong science learner identity drove her to achieve high grades in science any way:

> *My parents always asked me, 'How were your tests?', and I would say 'They were fine'. [But] my fine is different from their fine, I always tell them that. Of course, I passed because failure is not an option, passing to them is good [but] I am not happy with that, it must be an A-range for me to be happy.*

University science learner identity

Although the importance of learner identity for the academic success and retention of under-represented ethnic minority students is indicated by many researchers (i.e., Carlone & Johnson, 2007; Syed et al., 2011) and emphasised by the NZC (2007). It is also part of the Pasifika focus for Priority three of the Tertiary Education Strategy, 'Boosting achievement of Māori and Pasifika', which considers the provision of "opportunities that engage Pasifika learners as Pasifika within tertiary education" as an indicator of success (Ministry of Education and the Ministry of Business, Innovation and Employment, 2014, p. 14). Yet, this is not apparent in the University's Mission or Values. There are references to "*providing equal opportunities*" and creating communities where individuals are "*valued and respected*" (University of Auckland, 2012, p. 3) but no specific mention of learner identity. As discussed above, teachers are essential in the development of learner identity because of their involvement in the learning process (Siteine, 2010), especially ethnic minority students who are often isolated and exposed to stereotypes (Syed et al., 2011). Thus, the absence of learner identity is conspicuous and allows its importance to be overlooked by the University's organisational culture and teaching and support staff, ignoring possible ways to counter Pasifika academic underachievement.

This study argues that we must recognise the challenges Tongan (or any Pasifika/minority) science learners have faced in higher education. As in secondary school science, there are very few university-level Tongan science learners, often even fewer. In secondary school science, there may have been one or two students in a class of twenty; at university, it is more likely to be one or two in a class of fifty or more students. In the large stage one courses, there may be one or two Pasifika students in a class of hundreds (occasionally thousands). Ultimately, for those who are the 'only brown person in class', their presence often represents the culmination of a challenging academic journey. As stated previously, experience of the learning environment, interactions with peers, and emotional state inform science learner identity (Bandura, 1997). Being an ethnic minority has impacted on the participants' experiences of the University teaching and learning environment, informing their science learner identity as the stories below suggest.

Cohort ethnicity.

The dominant narrative in this section concerned the difficulty of being a minority ethnicity student in the University's learning environment: *"it's not easy, it's hard …looking around and there's not many Tongans around …it makes you want to do something else sometimes (Vaea, KOTE)".* It often led to feelings of cultural isolation: "*It sucks, because …the people around me are fine, it's that there is no-one else who I can relate to in that way, you know how the Tongan culture and values is a bit different" (Laulotu, ANZE)*.

Tinto (1975) argued that academic and social integration is necessary for student retention, with a well-integrated student more likely to continue. Critics of this view say that integration emphasises the need for assimilation or acculturation into mainstream systems, ignoring the cultural needs of ethnic minorities that may differ markedly from the institutional culture, thereby negatively affecting their academic performance (Johnson et al., 2007). They argue it is more important for the institution to adapt to the diversity of the student cohort (for example, Hurtado & Carter, 1997; Zepke, Leach & Prebble, 2006), particularly for minority ethnicity students who are likely to have different cultural backgrounds to that of the institution and the majority ethnicity students. Alternatives, such as considering student sense of belonging instead shifts the onus, so the institution is also responsible for student success; "[s]tudents' success is in part predicated upon the extent to which they feel welcomed by institutional environments and climates" (Johnson et al., 2007, p. 526). An example of institutional adaptation to diversity would be encouraging a shift in the learning environment so that it is learner-centred, an approach which is shown to aid in retention and completion (Zepke et al., 2006). Becoming learner-centred means that teaching staff are inclusive, treat their students fairly, and welcome and value the diversity of their students' cultural capital (Zepke et al., 2006). Although the University has aims and objectives in place to address Pasifika student success, it is necessary to determine if they are having any effect. Measuring variables of a learner-centred approach, such as inclusivity, would be required for this. Being a minority student also impacted on engagement in the science learning environment, particularly in courses with large class sizes. Despite the participants usually feeling excluded or isolated, several participants thought that the system and learning environments should not change to accommodate them because they were the minority. For example,

Takai: I wouldn't [usually] think about this because the education system now is set… but it doesn't [work for us]… it works for most people, but that's how things are, isn't it? You could get lecturers to realise that there are different ethnicities within their class, and they could be more sensitive about what they talk about in class… but that would affect their teaching, wouldn't it? It's because they don't know their audience.

SF: Whose responsibility is that?

Takai: The system, the teachers [but] they can't change the structure around how they teach to compensate, right? I see most students are non-Pacific and non-Māori, [in] my programme there are only two or three Islanders [so] I don't see the point of them changing.

Interactions with peers and teaching staff are one of the defining influences on students' sense of belonging (Hoffman, Richmond, Morrow & Salomone, 2002). Being part of a group that shares similar backgrounds, aspirations, and attitudes also makes it easier to adapt and to feel a sense of belonging.

Stereotyping Tongan/Pacific students taking science at university.

Peers had a significant influence on science learner identity in the University context. Participants described conversations that they had had with their peers about them taking science:

People say, 'Oh you are Tongan, you don't know that much'… students in my class say 'What are you?', and I say 'Tongan' and they expect me not to speak proper English, and I [think], 'I can speak properly, I am New Zealand born!' They [ask], 'Did you come from Tonga?' and I [say] 'No, I was born here', and they say 'Are you doing a Bachelor of Arts?', and I say 'What makes you think that?', [they say] 'It's, you know…' and I say 'I don't know, I am doing Science'. I am not the only Tongan that is [not] doing arts. We do all kinds of degrees… some other students prefer you not to do well or they think oh give it [until] next week, they won't be in class, they will be doing something else… I walk into my bio class, and there are times I am the only brown student. In other classes, there are three or four [of us], we are the only brown people… people give you a look like, I am sure you are in the wrong class, and we are no, I am enrolled here. I am supposed to be here… (Kalala, ANZE).

As discussed earlier, microaggressions and stereotype threat can affect how learners negotiate their narrated identities-in-practice and influence their embodied identities-in-practice (Tan et al., 2013). Not seeing other Tongan (or Pasifika) students in university science courses had implications for how some participants viewed science as a potential career

pathway. Laulotu (ANZE) suggested that a Pasifika science mentoring system would have helped her because it would make Pasifika science learner identities visible:

> *I don't know why there isn't a Pacific Island network in science already? There is in other faculties. That would be good, because I don't know of anyone who is doing science above me. There is no one above me who could tell me where I could go because I don't see any other Tongans doing science as well, so I don't know if [its possible].*

Stereotype threat often affected the participants' behaviour in class:

> *It depends on how your ethnic group is being portrayed, the stereotypes that surround you. You want to break out of them, but most of the time, when you try to break out of them, you are conforming, which is weird. I try so hard to come to uni and not fall asleep and be engaged, but most of the time, I end up conforming to the stereotype that I wag. That's not because we want to do it… but sometimes it's because of other reasons. When you do that you feel as if you let your race down, because everyone sees you, they don't see you as a person, as an individual, they see you as a Tongan, you represent every single Tongan, if you do something bad, every Tongan is bad, so there is that burden to carry around (Mele, KOTE).*

Several KOTE participants felt they had to prove their right to be studying at university. For example,

> *It's the whole stigma, being able to feel that you deserve to be there, you are constantly having to prove yourself because you are so different. For example, a lot of the [people] in my class, they are from [Decile 10 schools] ...I am the only one from [Decile 1 school] here, you know that they don't understand. We were in this [lecture]… and a Pālangi girl sitting next to me says 'I might go to Middlemore [for a medical placement] and I might need to stay out south'. The other girl goes, 'Don't go there, don't do it… if I was you, I wouldn't'. I looked at her, and she said, 'The closest I would go to South Auckland is Botany'… [I said] 'It's not that bad', and I had to navigate my way in that conversation not to come out as a defensive Tongan girl, but I felt hurt. Why is it bad, South Auckland? Why do you say that? And she said, 'No offense' to me… that kind of interaction is a common thing that happens to me. That doesn't help with your sense of belonging… I feel that they see South Auckland as a bad crime rate thing, it's because they see brown people… That pretty much sums up my interactions with general students in medical school ('Ana, KOTE).*

Sense of belonging affects confidence, achievement, and cohort relationships; when students have a sense of belonging, they are more likely to be confident, achieve academically, and have positive relationships with their peers (Booker, 2016). Unfortunately, many of the

participants' stories indicate they did not feel that they belonged as university science learners making it even more critical for this study to consider participants' feedback when attempting to address issues around engagement, enjoyment, and success in science within the higher education environment.

Referencing Tonga in the curriculum.

Tonga (or Tongans) were only mentioned in any course context as examples of poor health statistics and behaviours. Generally, KOTE participants questioned this negative portrayal:

> *One lecturer, she said that Tongans are big people and then compared them to Indians, and it was like you shouldn't be big because then you will end up having this [disease] in the end… [but] does it have to be a Tongan? Can it not be a man who overeats? I do understand what they are trying to say, if you meet a Tongan as a patient you must start thinking about these things, it's the way they presented it, it's not that positive (Setaita, KOTE).*

> *Only to Tonga in terms of health statistics yeah, Tongans have the worst this, that, this… It makes me feel that we are a burden; we are a burden to [Aotearoa] New Zealand, whereas it's the opposite, we add so much to this country, and they don't appreciate it ('Ana, KOTE).*

Interestingly, some ANZE participants seemed more accepting of this depiction:

> *Sometimes, it's a 50-year Tongan man comes to the hospital, always in that context… always bad health outcomes… that is the only time I ever hear about [Tongans]. It's negative, but I mean it's the truth, so at least they are getting that fact, and they must do something about it… (Vaka, ANZE).*

Teaching staff choosing to use these examples communicates a particular perspective to the group, a message that will understandably affect Tongan (and Pasifika) student learner identity and self-belief (Siteine, 2010) and the views of the wider cohort. In general, the participants felt perpetuating racial stereotypes in this way made them disengage. One ANZE participant liked the idea of using Tongan knowledge to teach content, but it contradicted with Aotearoa New Zealand society's perceptions of Pasifika:

> *…if they did [use Tonga as an example], it would be cool... [but]…you know how us Pacific Islands are always at the bottom of the spectrum? Why would they use Tonga as an example for something when they are going to teach that kind of stuff? (Laulotu, ANZE).*

The reasons for doing so would be precisely that, positively showcasing things acts to counter negative perceptions, influencing society through their exposure to positive examples. There is minimal research (i.e., none) on how negative portrayals of minority ethnicities in clinical scenarios affect the students using them, whether minority or non-minority. Therefore, the perspective of these successful students is essential; these stories highlight how necessary it is to consider the use of specific examples and analogies and the value of using any teaching and learning opportunity to value diversity and challenge stereotypes and assumptions, rather than perpetuating them.

Internalised deficit.

The following stories have been separated by educational grouping because there were some distinct differences. The KOTE participants often compared themselves with their peers, highlighting what they perceived as negative aspects about themselves, and the responsibility for perceptions of Tongan science learners. On the other hand, the ANZE participants also told stories about the negative perceptions of their academic abilities as Tongan science learners, but on occasion, they indicated that this perspective was somehow understandable or even acceptable.

KOTE participants.

As noted earlier, many KOTE participants' stories suggested internalisation of the deficit discourse they had experienced. They often made comparisons with their cohort, based on ethnicity and their perceived ability relative to their peers. Some felt that their strong Tongan learner identity and cultural involvement meant they did not know as much as everyone else. They then felt they were unprepared for the university environment, which prevented them from asking questions or interacting in the learning environment and eventually impacting on their final grades. For example,

> *I don't feel comfortable… it comes back to culture… At uni, its more European or white faces… it's also the idea in my mind that… they probably know so much, and I shouldn't interact because I might say something wrong or something like that… in lectures you always see, just them, it's always the general students answering questions… so you feel like a minor… I do study hard, but since I've been doing medicine, my highest grade is not even in the A range, [even after] studying so much, but it comes back to that… maybe it's not so much what you do now, more… if you were brought up, maybe it goes back to that, to your background or where you are from… (Mata, KOTE).*

The internalisation of this deficit thinking is evident in how KOTE participants interpreted different learning situations. For example, one participant described working collectively rather than individually in a lab class. They felt they were not as smart or prepared as the rest of their cohort because they took longer to answer the questions when working together:

> *Grace: we don't ask many questions because one, we are ma, and two… we don't want people to look at us and judge us because of our skin-color and because of the stereotypes that are already out there… you know that you have to learn it yourself, but we also know we are not at the same level as everyone else, so we have to pull each other up…*
>
> *SF: How do you know you're not at the same level?*
>
> *Grace: …if you get the question sheet, and we are only on question 2, and everyone else is on question 5… we talk to each, not gossip, but just helping each other in a way because we want to understand things and that might take time, especially with conceptual stuff like chemistry and physics, the answer might be 35 but the way and the concepts and theories behind getting the answer 35 are quite daunting.*

Working collectively in a manner that benefited their entire group is an acknowledgement of the importance of Pacific cultural capital, or 'polycultural'[57] capital (Mila-Schaaf & Robinson, 2010). Yet, rather than being able to celebrate working in a manner that was supportive and recognising that it may take longer to make sure everyone understands, they suggested that they were slower because of limitations in their abilities. Moreover, this meant that they needed more time to process and arrive at the correct answers. Being the 'only brown person' in their university science classes often made them feel responsible for perceptions of Tongan (or Pasifika) students:

> *When you walk around at uni, there are not a lot of brown people doing sciences. Being the only brown person in the room makes you feel inferior and scared, you have to prove something. When you get that notion into your head that you have to prove something it makes you lose the enjoyment and you start thinking I have*

[57] Although the term 'polycultural capital' was originally coined to refer to the cultural capital of Aotearoa New Zealand-born Pasifika, it is useful here because the university culture is new to all Pasifika, whether Aotearoa New Zealand or Island-born, so their cultural capital becomes very important during the transition to this new environment.

to beat this person, I have to beat this person, show we can be smart, and we can succeed in science (Mele, KOTE).

Occasionally, this was motivating:

[I] to turn it around and make it a positive thing, instead of demeaning us it empowers us, and that's the strategy I use now, so when people insult at me, I make it funny, it empowers me, it will no longer affect me in a negative way (Mele, KOTE).

Unfortunately, the KOTE participants are in learning environments where they feel this way. However, it is also positive that some of them appear to have the resilience to devise ways to maintain their self-efficacy.

ANZE participants.

Many ANZE participants spoke about local perceptions of Pasifika, their media portrayal, and how people talk about them. These views and experiences affected their self-belief and influenced how they behaved in class,

Lupe: I assume they [will] judge me, thinking that I am not listening, that I don't understand, that I shouldn't be there…

SF: Where does that thinking come from? Have you always thought that?

Lupe: I can't remember a time when I didn't.

The pervasiveness of this viewpoint meant some participants implied they could understand why their university peers made statements about their ability, for example,

[I] would get, 'Oh, you are really smart for a brown person, really smart for a Tongan' … Some of my friends say that, but at the time I didn't see it as [bad but] when you think about it, 'Oh for a brown person?'… but it's not their fault for them to say …it's the social influence of everyone (Laulotu, ANZE).

Participants even took on this rhetoric themselves:

I don't think it's easy [to study] science at university as a Tongan. There aren't many Tongans relative to everyone else, that makes it a bit harder, and sometimes your mind plays on you. You think there aren't many Tongans doing this, it must be hard for a Tongan to do this… sometimes I tell myself, this is out of your league, which is bad (Jake, ANZE).

The differences in these comments may relate to the earlier discussion around science learner identity and place of education; the KOTE participants have a much stronger science learner identity than the ANZE participants.

Implications for science education

I have already shared several examples of how my teaching practice has changed, such as acknowledging the *tapu* nature of reproduction by offering gender-specific tutorial classes (see Chapter Six: Implications for science education). The example I will describe here is a more recent example of engaging with Oceanic ways, the '*Ulungaanga faka-Tonga Fonu* model. This model (see Figure 7, below) acknowledges five '*ulungaanga faka-Tonga* (Tongan behavioural characteristics) needed for effective *talanoa* (Vaioleti, 2006). Embedding Tongan (and other Pacific) values by using a visual tool enables explicit discussion and demonstration of them in my university teaching and learning spaces.

The *'Ulungaanga faka-Tonga Fonu* model.

In Oceania, sea turtles (*fonu* in Tongan) are often sacred and have traditionally been important, especially in Polynesian chiefly society (Kirch, 1994; Allen, 2007). In parts of the Pacific, the ability of turtles to "transcend the boundary between the worlds of the land and the sea" has meant they have been likened to priests, including communicating the gods (Rolett, 1986, p. 87). According to Allen (2007), there is limited ethnographic evidence as to why turtles reached such an elevated status, she suggests that "turtles assumed such an elevated place in Polynesian cultures (as well as many Micronesian and Melanesian ones), [because] their habits of breathing, bleeding, crying, and tenaciously holding on to life, paralleling human characteristics, were probably important" as well as the reasonably unusual ability in animals of being able to survive in both water and air (p. 962). These 'habits' align well with those required by the participants' to achieve their goal of undergoing university-level science study. It was often a struggle to get through their secondary schooling, so breathing, bleeding, crying, and tenacity are essential qualities. The conceptualisation of fonu existing in two worlds also speaks to the need for the participants to border cross the learning gap between the worlds of their family and their formal academic western world.

The ‘*Ulungaanga faka-Tonga Fonu* model was used to foreground these ‘*ulungaanga faka-Tonga* and develop a type of ‘contract’ as to how we (staff and students) would all embody them (and any other values identified by the students) in the learning spaces. For example, all teaching staff would make sure we were prepared for all our classes to teach to the best of our abilities and to respond appropriately to situations that arose (*poto he anga*).

Figure 7*:* The ‘*Ulungaanga faka-Tonga Fonu* model: embedding Tongan values in teaching and learning spaces for effective teaching.

From the participants’ stories shared above it is clear they have had to battle many negative interactions during their science journeys. I believe that employing visual references that explicitly connect with Tongan cultural ideas demonstrates this knowledge is valued where and when I teach. It also displays my attempts to ensure my teaching is culturally sustaining, promoting the use of Tongan language in otherwise very western, English-

language dominated spaces. Regarding the KRF, I have used this model to consider how I rank and arrange (toli) the content of my courses to demonstrate the cultural importance of the IK in my learning spaces.

I recently started teaching in a non-Indigenous context and was concerned about how the things I had been learning about teaching would translate to this new space. I deliberated over whether or not to show the '*Ulungaanga faka-Tonga Fonu* model to my class of 300 students of mixed ethnicity (a tiny proportion of whom are Pacific). I was not sure they would respond or how presenting Tongan values in this way would impact on any Tongan students in the class (i.e., trigger microaggressions or stereotype threat). Nevertheless, I have learnt that I must foreground the values of the learning spaces in the first interactions I have with my students before I deliver anything else, signalling what I consider is acceptable and valued. Therefore, I showed the model in the first lecture and then again, a few weeks later. It seemed to be well received but I did not know for sure.

Two months after I first showed it, a non-Indigenous student contacted me regarding concerns about noise levels in the learning spaces. They referred to the model, noting the importance I had placed on it, and asked me to remind students about their shared responsibilities (*faka'apa'apa*, *poto he anga*, and *anga lelei*) to ensure the learning space is respected. I believe this explicit discussion of values helps with relationships and interactions and positions me as a university educator who cares about students' learning experiences. It also demonstrates how non-Indigenous students can benefit from engagement with Tongan cultural value systems.

Concluding comments

Teachers usually allocate their students a learner identity rather than affirm one they already hold; for Pasifika students, this can "promote fixed, unrealistic, fragmented and singular identities" (Siteine, 2010, p. 9). Although, many participants in this research regularly demonstrated competence in their science studies, their teachers and/or peers did not consider they had a strong or positive science learner identity. This deficit perspective of Pasifika science learners must be addressed, as inequalities and expectations around ethnicity influence how students identify with science (Wong, 2015). The following chapter

presents an alternative to the deficit perspective, requiring educators to reflexively change their practice to better enable Tongan and other Pasifika science learners success.

Chapter Ten – Oceanic theorising: *Vale, ʻilo, poto?*

The drive to make education more culturally relevant and responsive to the needs of Pasifika learners is not new. Nevertheless, most of Aotearoa New Zealand's formal secondary and university-level curriculum and pedagogy continues to reflect western values and knowledge sources despite attempts by various education policies (i.e., PEPs, the NZC (2007), the TES) to be more inclusive of Pasifika cultures. Acknowledging Pasifika culture in education has many benefits: including alternative wisdoms increases the relevance to more students; and allows different ethnic groups to learn from each other and improve their relationships, with immediate benefits for society. According to Thaman (2003), "[v]aluing indigenous ways of knowing usually results in mutually beneficial collaboration between indigenous and nonindigenous peoples, and improves their treatment of each other as equals." (p. 11).

One example of embracing IK in this research is the use of the KRF. As outlined in Chapter Two, *kakala* are a significant aspect of Tonga culture. Woven through this research is the metaphor of *kakala* making and gifting as an approach to education research (see Thaman, 1997; Fua et al., 2007): Chapters One and Two outlined *teu*, the conceptualisation of the study; Chapter Three described *toli*, or data collection, and *tui*, or data analysis. The final three stages, *luva*, *mālie,* and *māfana* provide this chapter with a framework for the thesis conclusion.

Luva and *Mālie*

Critiques of previous attempts to improve Pasifika student achievement highlighted the exclusion of Pasifika pedagogy, deficit thinking regarding Pasifika students, and the negative influence of Pasifika values on success (Nakhid, 2003). Nahkid (2003) also noted the frequency of linking Pasifika academic failure or underachievement with Pasifika students' *"*inability to come to terms with the culture of a European education system*"* (p. 299). In response, this research focused on successful Tongan science learners, students who had achieved academically in the western education system. *Luva*, the outcomes of the study and *mālie*, its relevancy and worthwhileness, are discussed next.

Vale: Moving away from ignorance.

This research has presented the stories of 26 successful Tongan science learners to counter the predominantly deficit views of Pasifika (and Pacific) students and education. Three research questions framed the exploration of their experiences to determine their definitions of engagement, enjoyment, and success; how engagement, enjoyment, and success were encouraged (and discouraged) by teaching and learning practices; and what science and ISK meant for successful Tongan science learners. These questions guided how this research considered their experiences, knowledge, understanding, and attitudes towards their formal science education at secondary and university-levels and their exposure to ISK.

Much has been made of the 'impact' of Pasifika underachievement for Aotearoa New Zealand's economic development while overlooking the 'importance' of Pasifika achievement and 'interplay' between western and IK in science teaching and learning spaces. Importantly, the narratives in this research present the impact of negative social and academic expectations both within and outside the education system on Tongan science learners. They also provide valuable insights into how Tongan science learners consider, understand and experience engagement, enjoyment, and success; their particular cultural lens broadens our understanding of these concepts by providing a viewpoint that has been missing previously. The narratives also describe the importance of engaging, enjoying, and being successful in science for family and community reasons and the dearth of references to, or engagement with, ISK in their formal education experience in Aotearoa New Zealand. Furthermore, their stories acknowledged the importance of recognising the heterogeneity that exists within and between Pasifika/Pacific populations and valuing the education systems of the Pacific.

Half of the participants in this research spent time in the Tongan education system; most described the importance of their Tongan education for their academic journeys and its contribution to a positive science learner identity. Comparisons between Aotearoa New Zealand and Tonga highlighted two very different education systems, providing perspectives on the Tongan science education experience and a narrative to understand the myths created about education in Tonga. The participants' insights have also substantially enhanced the understanding of how Pasifika/Pacific cultural values and knowledge can inform secondary- and university-level science education. We have gained a deeper understanding of how they define engagement, enjoyment, and success, and how they have experienced

them in science teaching and learning spaces. Woven throughout this thesis are stories of my critical self-reflection. Informed by these participants' experiences of teaching and learning practices in secondary and university-level science education, these reflective stories tangibly demonstrate the potential to positively impact the interplay between Indigenous and western ways of being in science education.

'*Ilo*: Gaining knowledge.

Thaman's poem 'Our Way' was used in Chapter One to demonstrate differences between Indigenous and western ontologies and epistemologies. In this final chapter, I use it to briefly illustrate the critical self-reflective practice I have engaged in, particularly over the last seven years of my (part-time) doctoral study. My reflection has shifted me further from the *Pāpālangi* ways of my ancestry and of my upbringing, as a science educator and a mum, wife, friend and sister to my Pacific kainga, as an Oceanic researcher, an external insider. I believe I am better equipped to explain the confusion I identified in Chapter One regarding my science studies; I now realise that I never completely bought into the positivist view of science I learnt about as a student. I struggled with the WMS position as "objective/analytic/always doubting/the truth/until proof comes slowly" (Thaman, 1987 stanza 1). As a result, I have long wrestled with philosophical questions around which knowledge or conceptualisations of the world are more accurate, true or real. For example, how can I believe in the power of a higher spiritual entity or entities if I also accept many aspects of WMS science? Furthermore, are these two things even mutually exclusive?

The theoretical musings required for this research, albeit a struggle and an area I avoided as long as possible, enabled me to understand how I can simultaneously hold seemingly conflicting beliefs, how I can be "subjective/gut-feeling like/always sure of the truth/the proof/ is there/waiting" (Thaman, 1987, stanza. 2). Now, I am so much comfortable with not compartmentalising my thinking, not forcing myself to be objective or discrediting gut instinct, superstitions, or more traditional (i.e., pre-Christian/Colonial) wisdoms. I can confidently explain that Indigenous and western bodies of knowledge are different because they are founded on different principles, underpinned by different foundations. My musings have also provided me with tenets to consider and inform who I am, how I think about things, and of course, how I approach my teaching and learning contexts. During this research, I have considered far more than the delivery of WMS and Tongan science learners in Aotearoa New

Zealand and Tonga. I have also begun to examine the interface between WMS and ISK in formal science education, particularly in Aotearoa New Zealand. How the four theoretical frameworks employed in this research have supported this are outlined next (see Figure 8).

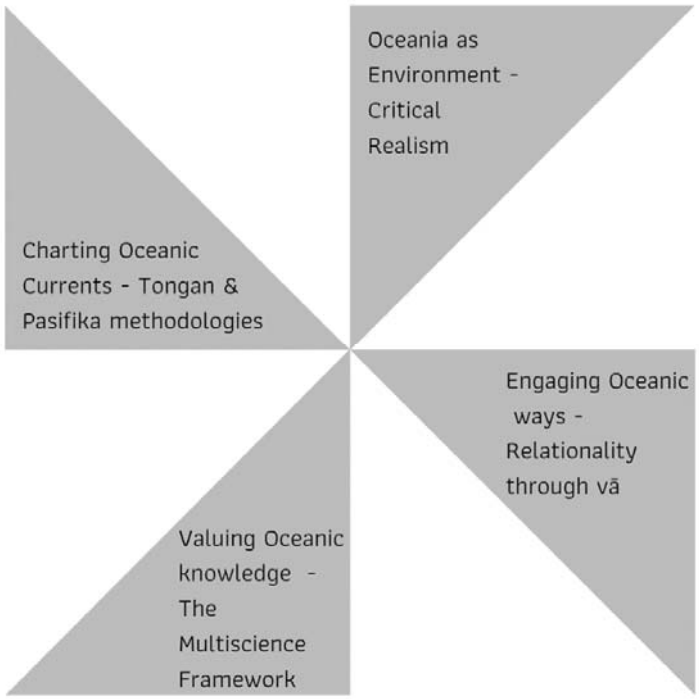

Figure 8: *Lalanga manulua*: Using *manulua* to depict the four theoretical frameworks of this thesis.

Critical realism.

Critical realists emphasise the importance of considering the history of a situation to be able to contextualise the stratification by time, and acknowledge that changes in different levels will have potential impacts on the various levels or strata. The 'stratified ontology' aligns well with the Tongan concepts of *tā* (time) and *vā* (space), which are essential when considering relationality and spatio-temporality in Tongan culture and society. This perspective allows and acknowledges that different cultures have different arrangements and understandings regarding time and space, which can create conflict when they are forced together under one cultural interpretation (Māhina, 2008). Importantly, critical realism emphasises the analysis of social relationships that occur within social structures. This

aligned well with the idea of examining relationality, as *vā* in this thesis, especially with the emphasis on the importance of relationships in Tongan society.

Vā and relationality.

Understanding *vā* can explain so much about what is absent or problematic in the culture of WMS and the delivery of science curricula influenced by WMS. Ignoring or downplaying the relationality between two people or entities (living or non-living) suits the projection that WMS is objective, neutral, and controlled by humans. Employing a critical lens explains how this is impossible. Humans are inherently subjective and, like all knowledge, influenced by context and the culture of the setting, whether that is in society, a science classroom or a laboratory. This cultural context also affects how we view knowledge and the boundaries around what is considered valuable knowledge.

The Multiscience framework.

Teaching science from a Multiscience perspective acknowledges that other sciences exist and drives "richer implications for reflection and practice" for science educators (Ogawa, 1995, p. 583). Additionally, a Multiscience approach acknowledges that non-western students are continually negotiating the demands of their formal western education and their cultures (Thaman, 2010), a process described by some as 'cultural border crossing' in science (Aikenhead, 1996). If science teachers understand and adopt a pluralistic perspective of scientific thinking, rather than assuming universalism, it opens the opportunity to include IK and, subsequently, culturally responsive and culturally sustaining science education.

Pacific methodologies.

Underpinning this research with Tongan and Pacific methodologies acknowledged the importance of traditional values and epistemologies (Anae et al., 2001). It was essential for me as an external-insider to reflecting on how to employ cultural practices and concepts emphasised by the KRF, such as *talanoa*, *mālie,* and *māfana*. This reflection has strengthened this research and my understanding of what it means to be an Oceanic researcher. It has also demonstrated why I, and other non-Indigenous science educators and researchers, must embrace methods that are more culturally sustaining of participants, but also students.

Māfana

I have always been explicit that my commitment to this research and to the successful Tongan science learners who participated in it was that it would be 'socially transformative educational research' (Burnett, 2012) and align with RPEIPP. As discussed previously, I have spent twenty years working as an educator at university, struggling with the idea that Pasifika students were more likely than others to fail in the courses I was teaching. Regardless of years of experience, I needed to be critical and self-reflexive to deepen my understanding and move myself from *vale* to *'ilo* and to(wards) *poto*.

The final stage of the KRF is *māfana*, the application, and transformation of the research, in this case, the application and transformation of science education after hearing the stories of successful Tongan science learners. I believe this research's findings will help to transform aspects of science education in Aotearoa New Zealand, at the very least by providing a platform to engage with the previously unheard stories of successful Tongan science learners. Importantly we now know more about their experiences in the education system in Aotearoa New Zealand, and for the KOTE participants, their experiences of education in the Kingdom of Tonga. These stories have strengthened our understanding of Tongan science learner experiences, how they define engagement, enjoyment, and success in science, and which teaching and learning practices support these aspects. We also know more about the importance of valuing and explicitly employing TSK in secondary and university science education. The next challenge is for science educators to consider how to engage with this information; I offer a suggestion below, the Fakahila framing.

Identifying *poto* – my contributions to the scholarship of Tongan/Pasifika/Pacific/Oceanic/Moanan education.

I believe the stories told by the ANZE participants, in particular, provide an essential commentary on their education experience in Aotearoa New Zealand. One which demonstrates the symptoms of internalised belittlement inherited by those of the younger Tongan (and other Pasifika/Pacific) generation who reside in Aotearoa New Zealand and view the Kingdom of Tonga, other Pacific Island countries and the Pacific Ocean, from afar. Is this the perpetual sense of inferiority and inadequacy described by Hau'ofa (1993) to be urgently addressed in Pacific education in Aotearoa New Zealand?

As highlighted earlier, Randy Thaman's (1993) response to 'Sea of Islands' argued that "smallness and isolation actually offer great potential for promoting independence from belittling and derogatory influences" (p.41). Culturally sustaining pedagogy seeks to avoid essentialising (Paris, 2012). Therefore, we need to identify nuances and complexities in cultural differences within ethnicities. By separating the two participant groups, we can locate considerable heterogeneity. For example, it would seem that the KOTE participants' education experiences have avoided the belittling and derogatory influences described by the ANZE participants. As science educators, I believe we have a responsibility to recognise our role and agency to shift perceptions and, subsequently, student experience. Culturally sustaining pedagogy asks that we consider "explicit resistances that embrace cultural pluralism and cultural equality" (Paris, 2012, p. 95-96) as without such resistances, students will continue to be asked

> to lose their heritage and community ways with language, literacy, and culture in order to achieve… And this saga of linguistic and cultural loss has had and continues to have devastating effects for the access and achievement of students and communities of color.

Fakahila.

The calls to embrace Pacific ways and knowledge as a means to decolonise and disrupt western systems or practices in the Pacific have played a significant role in the realisation of this study. I have responded to the charges to remember Pacific/Oceanic ways by prominent Tongan scholars such as Hau'ofa, Helu, Taufe'ulungaki and Thaman, to the more recent urgency raised by Fa'avae (2019). My response has been to privilege Tongan knowledge in this research by embracing various Tongan concepts including *ako*, *mālie*, *māfana*, *tauhi vā, fanongo, fatongia* and *faka'apap'apa*. Hau'ofa's Sea of Islands essay and his colleagues' responses have been integral to how this thesis has been woven together. It has anchored together the four theoretical frameworks, distilling many ideas into what I believe is a comprehensive demonstration of what happens when '*ilo* (knowledge and understanding) is used appropriately and positively (Thaman, 1995).

In response to Hau'ofa's essay, Subramani (1993) wrote, "the decolonising Pacific Islander inevitably returns to pre-contact Oceania to reimagine the unity and connectedness of things" (p.27). As a decolonising Oceanic researcher and educator, I am looking to pre-

contact Tonga to reimagine ways to consider Tongan science learners in our classrooms. I offer a metaphor, Fakahila, to transform science teaching and learning spaces.

The *Fakahila* metaphor

Fakahila is a Tongan word that means "to look with a quick turn of the head" (Rabone, 1845, p. 59). It is word consisting of two parts: *faka-* which is commonly used in the Tongan language to form compound words and signifies, as a prefix to verbs, nouns and adjectives, 'after the manner of' or 'to cause' (Rabone, 1845, p. 38); and *hila*, a verb that means "*to look askaunt; to turn the eyes about*" (p. 128). A later Tongan dictionary groups *fakahila* with *fakahilatuamata* (to look askaunt) and *fakahilehila* (to look as from under a hat) which perhaps provides more clarification and description of what this term is acknowledging (Baker, 1897, p. 50).

I first heard the term when my husband explained to me many years ago why he looks at people when they are speaking, or objects such as the television, with his eyes at a distinct angle. When I asked why he tilted his head and eyes rather than re-positioning his body, he said he was *fakahila* and said, "this is how I look at things, why should I change it?" This word fascinated me, particularly as I could think of no equivalent in English. I was intrigued because there was a word for this physical positioning of self. According to Taumoefolau (2017), "[a] word is not a word unless it represents some kind of meaning… The meanings of words in a given language more or less define or represent a people's collective experience of life within the scope of their particular culture" (p. 138). What I considered from my *Pāpālangi* positioning as something to be fixed, he considered his positioning as an explanation.

For my husband, being *fakahila* means he remembers his past and his ancestry, thus he has developed his knowledge by considering the world in a different way. In his words,

> my normal is far from what someone who is not fakahila looks at or thinks. It's more about, looking straight is fine, but if you tilt your head slightly and your eyes as the vision of your brain, your brain thinks slightly differently, your brain asks different questions. The tilt or side glance allows a shift; my brain tilts to acknowledge disagreement. But if looking at something, wanting to know something, the thinker is trying to figure out the world, they are not happy with the solution given to you by the straight-eyed… I dig deeper to find the truth… as a Tongan now, fakahila means I don't settle on the truth I have been fed [by westernisation]. I do not settle, instead I have an uncontrollable urge to know the truth.

A key finding of this research is the need for educators to shift their gaze slightly. Fa'avae (2019) argued that for indigenous researchers, "disrupting ingrained thinking is possible when using Tongan or Moana people concepts that allow for deconstructing, re-focusing, and rethinking that is centred on Indigenous views of the world" (p. 6). I suggest that *fakahila* offers this Tongan view of the world. I see it as an appropriate metaphor to conceptualise a way of thinking about science education and how we approach teaching and learning for Tongan and other Pasifika/Pacific learners. I believe it distinguishes a particular perspective or viewpoint that is different to the usual, perhaps more mainstream, way of considering things. By this I mean, the existence of the term *fakahila* recognises and acknowledges the ability to view or think about things from a slightly different perspective in Tonga culture.

During my considerations of *fakahila*, I had the privilege to *talanoa* with Dr. Melenaite Taumoefolau, a renowned Tongan linguist. For her, *fakahila* is a word found in the commoner language[58] that describes a shift in the eyes, often accompanied by a pause in dialogue. From her understanding and experience, *fakahila* is sometimes regarded negatively, akin to people being left-handed in other cultural contexts, and it is discouraged because it is unusual. Furthermore, it is hard to gauge what someone who is *fakahila* is looking at or paying attention to. I believe these insights add further weighting to the value of *fakahila* as a metaphor for adjusting the way of seeing. *Fakahila* is only perceived as unfavourable because it is unusual, not because it is wrong or bad. Offering any narrative that counters the dominant viewpoint is always a challenge; it does not make it wrong or bad either. I believe that the pause associated with *fakahila* offers an opportunity for teachers to stop and consider another way of delivery, rather than assuming the 'straight-eyed' or dominant viewpoint is the correct one. *Fakahila* creates an expectation of reflection before decision-making, informed by an understanding of the audience, the context, or the topic of discussion. Embedding such a perspective in our approach to science education and how it is delivered, we could transform science education.

As a metaphor, *fakahila* is also relevant beyond Tonga. A linguistic study by Ranby (1980) on the Polynesian language spoken in Nanumea, the northernmost island of Tuvalu,

[58] There are multiple different ways of talking in Tonga depending on who is being spoken to or about. For example, *lea fakatu'i* is for talking to or about the king, and *lea tavale* or the way of speaking to commoners (*tu'a*) (Taumoefolau, 2012).

lists the term *fakahila*. This reference describes *fakahila* as "to look sideways at", as *hila* refers to being "unable to see properly out of one eye" (Ranby, 1980, p. 29), and *faka* is also described as a causative prefix that can "cause an action to occur or a state to result" (p. 12). That *fakahila* exists in other Polynesian languages suggests that this concept has relevance for other Pasifika students, not just Tongan science learners. Thus, *fakahila* aligns well with the positioning of this research that acknowledges the heterogeneity of Pacific/Oceanic/Moanan populations while at the same time recognising the shared ancestral relationships and connections through language, familial lineages, creation myths, and stories.

Fakahila also sits well within the global context of Indigenous pedagogies or philosophies proposed to address indigenous student engagement in science education and the valuing of IK. These also include references to visualising knowledge or perspectives from an indigenous viewpoint to address concerns around indigenous engagement and success in science. Examples include 'both ways' (or two-ways) seeing from Australia and 'two-eyed seeing' from Canada as philosophical approaches to pedagogies when considering indigenous (science) education. These pedagogical approaches can bring together indigenous and non-indigenous knowledges and ways of knowing to demonstrate how they complement rather than exist in conflict with each other (Michie, Hogue & Rioux, 2018). For example, with 'both ways' seeing education is informed by combining *"*together Indigenous Australian traditions of knowledge and Western academic disciplinary positions and cultural contexts*"* (Batchelor Institute, 2007, p. 8).

In Canada, 'two-eyed' seeing values the insight that comes from multiple perspectives (indigenous and western); with the belief that a deep and informed perspective results from combining one eye seeing the strengths of indigenous ways of knowing and the other eye the strengths of western ways (Michie et al., 2008). Two-eyed seeing, combining the seeing of one eye with another, can also represent the seeing of the external or physical eyes to enable the inner eyes (i.e., the brain) to focus or concentrate on finding its perspective (Taumoefolau, 2019 pers. comm). If *hila* means to glance or a glance, and *faka*- causes a glance, one that is more deliberate or delivered at an angle, then *fakahila* induces the glance to take a particular stance.

As educators we need to consider how a slight shift in the way we think allows us to recognise what or how another person looks at things or feels. If we return to the earlier reference to *manulua*, it is possible to demonstrate visually what is being asked of educators here.

Figure 9: Ngatu featuring the manulua motif. Artists unknown, (year of work unknown). Author's family's personal collection.

Looking at the central panel of this *ngatu*, the viewer can see the repeated pattern that is commonly referred to as the *manulua* (Figure 10) and used throughout Chapter Two to explain the four theoretical frameworks informing this thesis: critical realism, relationality, the MSF and Tongan and Pacific frameworks. Yet, a slight shift or *fakahila* to either side of this motif, exposes a second way of viewing (Figure 11), one where the *manulua* or two birds can be seen connecting differently, a move that suggests an even or equal connection. This

depiction can demonstrate how considering ISK and WMSK together creates something new, a metaphor for how science educators could draw on both bodies of knowledge to teach their students about the world.

Figure 10: Close up of *ngatu* featuring the *manulua* motif I. Artists unknown, (year of work unknown). Author's family's personal collection

Figure 11: Close up of *ngatu* featuring the *manulua* motif II. Artists unknown, (year of work unknown). Author's family's personal collection.

Assuming a position akin to *fakahila* aligns well with the ideas of critical realism, relationality, Multiscience, and Tongan and Pasifika methodologies outlined above, by recognising the value of different perspectives and knowledge, the importance of language, and what is considered to be real. As science educators, we need to find ways to be more inclusive of other knowledges, particularly IK. Therefore, sharing how we view things can bring an understanding of how others see the world. This disruption is important. I propose that the *fakahila* metaphor allows teachers to consider different possible perspectives and choose the one that best fits their students even if they have to *fakahila* themselves and look in a different direction away from what they are comfortable with or are used to.

Vale, 'ilo…

In the 'Sea of Islands', Hau'ofa urges his audience to recognise (and remember) the importance of all relationships, particularly relationships with non-living entities such as the ocean. Science education is a unique space in which we can present, recognise, and value the interconnectedness and contribution of all things, as well as the thinking of different groups, cultures, and entities. If we do not, we run the risk of degrading and losing "the myths, genealogies, technologies, plant and animal names and their uses, and the traditions that

give Pacific societies positive self-images and autonomy" (R. Thaman, 1993, p. 45). I believe science educators must recognise that our ontological positioning influences many aspects of the education process, including the content covered, the examples used, and the pedagogical approach undertaken.

Arguably, this research provides a valuable narrative from Tongan science learners regarding their experiences in secondary and university-level science, both in Aotearoa New Zealand, and the Kingdom of Tonga. Their stories indicate that there are considerable structural limitations and boundaries created (perhaps inadvertently) by institutions and educators that prevent our Tongan and Pasifika/Pacific science learners from succeeding. If we consider that, "in the days when boundaries were not imaginary lines in the ocean, but rather points of entry that were constantly negotiated and even contested. The sea was open to anyone who could navigate his way through" (Hau'ofa, 1993 p.9), it is possible to imagine that by removing these imposed boundaries, more learners will succeed. I would argue that we need to understand better how science educators can create settings that support more Tongan science learners to be successful and how to disrupt these limitations and boundaries.

Many attempts have been made to improve Pasifika academic success in the tertiary education space, yet Pasifika students still do not succeed on par with other ethnicities. Instead of finding ways Pasifika students can change so that they succeed, I believe we must purposefully and explicitly focus our energies and efforts more on the teaching staff/educators and institutions as the locus for change. We must assist them in building their cultural capacity and critical self-reflection so that they can understand and engage with Tongan (and Pasifika/Pacific/Moanan) science learners, not expect it to be the other way around.

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Appendices

Appendix A – Advertisement

Epsom Campus
Gate 3, 74 Epsom Avenue
Auckland, New Zealand
Telephone 64 9 623 8899
Facsimile 64 9 623 8898
www.education.auckland.ac.nz

The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

THE UNIVERSITY OF AUCKLAND
FACULTY OF EDUCATION
Te Kura Akoranga o Tāmaki Makaurau
Incorporating the Auckland College of Education

TONGAN STUDENTS WHO ARE STUDYING SCIENCE: BIOLOGY, CHEMISTRY OR PHYSICS

Are you a Tongan student majoring in biology, chemistry and/or physics or taking these types of courses in your degree?

Have you successfully passed two or more Stage 1 courses in biology, chemistry or physics (or their various alternatives) at the University of Auckland as part of your degree? Or have you recently graduated (i.e. in the last three years) in a degree with a science focus?

If so, we would love to talk to you about your experiences.

We want to gather Tongan students' experiences of studying science at the University of Auckland. We want to find out more about what makes you engaged, successful, enjoy and achieve in science, what teaching practices help or hinder you and what it means to be a Tongan student studying science at university.

The research involves an individual interview with a student researcher who also teaches science at the University of Auckland.

This study only seeks students who have passed two or more Stage 1 courses in biology, chemistry or physics (or their various alternatives) at The University of Auckland, and are currently enrolled or recent graduates from the last three years.

You will be provided with food and a voucher of $40 to thank you for your time.

Any questions?

If you have any queries or wish to know more please contact:

Sonia Fonua (Student Researcher)

Telephone 09 3737599 extn. 89710.

Email: s.fonua@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 08/04/2015 for 3 years,
Reference number 014009

Appendix B – Participant Information Sheet

School of Critical Studies in Education

THE UNIVERSITY OF AUCKLAND
FACULTY OF EDUCATION
Te Kura Akoranga o Tāmaki Makaurau
Incorporating the Auckland College of Education

Epsom Campus
Gate 3, 74 Epsom Avenue
Auckland, New Zealand
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Facsimile 64 9 623 8898
www.education.auckland.ac.nz

The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

Tongan students and science: Engagement, retention, achievement, enjoyment, and success.

Participant Information Sheet

Malo e lelei, my name is Sonia Fonua and I am a doctoral student in the School of Critical Studies in Education, in the Faculty of Education, The University of Auckland supervised by Associate Professor Eve Coxon. I would like to invite you to participate in a study about the experiences of Tongan students and their science studies at university. Your participation in the study is entirely your choice (voluntary) and anything you say will not affect your access to educational services, your academic performance or your relationship with The University of Auckland academic and support staff. If you agree to take part in the study you are free to withdraw from the study at any time without having to give a reason, and this will not affect your studies. If you are willing to take part in the research, we will contact you in approximately one week.

About the study
The aim of the study is to find out about your experience of learning science, in particular at university so we can improve the experience for other Tongan students in the future. In this context, science is defined as a focus on biology, chemistry, and/or physics, and their various alternatives.

If you decide to participate I would like to interview you in a semi-structured individual interview.

Approximately 20 people will take part in this study.

The interviews will take place in various venues across the University of Auckland or wherever is convenient for the participant.

Who is invited to participate in the study?
Students at the University of Auckland who identify as Tongan and who have passed at least two Stage 1 courses in biology, chemistry or physics (and their various alternatives) in their current degree or a degree they have recently graduated from (i.e. in the last three years) are invited to participate in this study.

What is involved?
The individual interviews will take between 40 – 90 minutes. Interview participants do not have to answer all of the questions and can stop the interview at any time. These interviews will take place at the University of Auckland or other places of your choice. With your agreement, the interviews will be digitally audio recorded. You can choose to have the audio recorder turned off at any time during the interview. The audio recording will then transcribed (typed out) by the researcher or a research assistant (if the interview is conducted in Tongan) and be kept as a password protected electronic file for six years. You will be given the choice of receiving a typed copy of your interview to read, check or withdraw any information you do not want used in the study. You will have six weeks to make changes or withdraw information from your individual interview.

You may also be asked to participate in a follow up interview to track your continued progress up to one year after the initial interview.

Confidentiality & privacy
No material that could personally identify you (let other people know who you are) will be used in any reports on this study. Identity of individual interview participants will be kept confidential. Information collected from the study will be stored in a locked cabinet or as a password protected file on University of Auckland premises,

separate from participant consent forms, for a total of six years. After this time, all data will be destroyed according to The University of Auckland's disposal procedures.

Results and dissemination
The study will finish in May 2021. Information from the study will be used to improve teaching and learning at The University of Auckland as well as inform services, especially for Tongan (and other Pasifika) students. The findings from the study will be presented in academic publications (journals and books), to education providers (secondary and tertiary), at academic conferences, and reported back to the community through oral presentations and through summary documents. As a participant in the research you will be able to receive a summary of the key findings, their meaning and their significance upon request.

Risks and benefits
There are no direct risks or benefits to you as a participant in this study. There is also no cash payment for your participation in the study. You will be provided with koha ($40 book voucher) in appreciation of giving up your time for the study (even if you decide to withdraw from the study after the information is collected).

Any questions?
If you have any queries or wish to know more please contact:

Sonia Fonua (Student Researcher)
Telephone 09 3737599 extn. 89710.
Email: s.fonua@auckland.ac.nz

Assoc. Professor Eve Coxon (Principal Investigator)
Telephone 09 3737599 extn. 87986.
Email: e.coxon@auckland.ac.nz

Assoc. Professor Carol Mutch (Head of School)
Telephone 09 3737599 extn. 48257.
Email: c.mutch@auckland.ac.nz

For any queries regarding ethical concerns you may contact:
The Chair,
The University of Auckland Human Ethics Committee
The University of Auckland
Research Office
Private Bag 92019
Auckland 1141
Telephone 09 3737599 extn. 87830/83761.
Email: humanethics@auckland.ac.nz

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 08/04/2015 for 3 years, Reference number 014009

Appendix C – Consent Form

School of Critical Studies in Education

THE UNIVERSITY OF AUCKLAND
FACULTY OF EDUCATION
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The University of Auckland
Private Bag 92601, Symonds Street
Auckland 1150, New Zealand

Tongan students and science: Engagement, retention, achievement, enjoyment, and success.

Consent Form

This form will be kept securely for a period of six years. Please circle yes or no for each question. If you have any queries or wish to know more please contact:

Principal Investigator: Assoc. Professor Eve Coxon
Telephone 09 3737599 extn. 87986.
Email: e.coxon@auckland.ac.nz

Student Researcher: Sonia Fonua

- I have read and understood the participant information sheet for this study. I understand how and why I have been invited to participate in the study and I have been able to ask questions and have them answered in a way I understand.
- I understand that my participation in this study is my choice (voluntary) and I may withdraw from this study at any time without having to give a reason.
- I understand that my participation in the study will not affect my education or academic results and it will not affect my relationship with The University of Auckland academic and support staff.
- I understand that I do not have to answer all of the interview questions and I understand that I can stop the interview at any time.
- I understand that no information which could identify me (let other people know who I am) will be used in any reports on this study.
- I agree to the interview being digitally audio recorded.
- I understand that I can choose to have the audio recorder turned off at any time during the interview.
- I understand that if I want, I will be given a typed copy of the interview to read, and I will have six weeks after being given the interview to change or withdraw any information I do not want used.
- I want to be given a typed copy of the interview.
- I understand that the audio recorded interview will be kept as a password protected electronic file on The University of Auckland premises, separate from participant consent forms, for a total of six years. After this time, all data will be destroyed by according to The University of Auckland's disposal procedures.
- I understand that data from the study will be used to improve education services, presented in academic publications, at academic conferences, and reported back to the community through oral presentations and through summary documents.
- I agree to take part in the research.
- I agree to take part in any follow up interviews

Yes/No

Participant's name_____

Participant's signature_____

Participant's contact details_____

APPROVED BY THE UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE ON 08/04/2015 for 3 years, Reference number 014009

Appendix D – Interview Schedule

Individual Interview questions

These interview questions follow the five key research questions of this research project. They are broadly constructed to allow the interviewer to probe or go more deeply into an area as indicated by the participant's narrative. The questions are open ended to allow the participant to tell their story, with the interviewer prompting as required to clarify and explain using the following types of phrases: "can you talk me more about … ", "what do you mean by …", "is there more you would like to say about …", "do you have other examples of …".

As this interview is using the Tongan methodology of *Talanoa*, it is important to acknowledge the silences and allow the participant to use silence as a way of conveying meaning.

The session will begin with a brief overview of the project purpose and allow time to make proper introductions before the interview itself begins.

Overview:

Discussion of anonymity/confidentiality/language

Interview format:

1. Can you tell me a little bit about yourself? (Positioning the student)
    a. Where were you born?
    b. Where did you complete your secondary school education? (If Tonga, when did you come to Aotearoa New Zealand (ANZ). If a combination of ANZ and Tonga, why?)
    c. Did you take science[1] subjects (biology, chemistry or physics) at secondary school? To what level? (If yes, why? If no, why not?). How did you go? (Explore any difference of the three sciences for each individual).
    d. Did you come straight to bachelors study after school? (If no, why not?)
    e. What programme are you studying (What year are you in? Which science(s) do you study?)

2. Tongan student success in science:
    a) What does success in science mean to you? How would you define it?
    b) What helped your success in science at secondary school?
    c) What helps/has helped your success in science at university?
    d) What hindered your success in science at secondary school?
    e) What hinders/has hindered your success in science at university?
    f) How did you overcome this at secondary/university?

3. Tongan student engagement in science:
    a) What does engagement in science mean to you? How would you define it?
    b) What helped your engagement in science at secondary school?
    c) What helps/has helped your engagement in science at university?
    d) What hindered your engagement in science at secondary school?
    e) What hinders/has hindered your engagement in science at university?
    f) How did you overcome this at secondary/university?

[1] In this context, science is defined as a focus on biology, chemistry, and/or physics, and their various alternatives. This will be explained to the participant at the beginning of the interview.

5. Teaching and learning practices:
    a) Which teaching and learning practices at secondary school or university have helped you to keep studying science? (Which hindered you?)
    b) Which teaching and learning practices at secondary school or university have helped you to succeed in science? (Which hindered you?)
    c) Which teaching and learning practices at secondary school or university have helped you to engage in science? (Which hindered you?)
    d) Which teaching and learning practices at secondary school or university have helped you to enjoy studying science? (Which hindered you?)
    e) What does achievement mean for you? How would you define it?
        i. Which teaching and learning practices at secondary school or university have helped you to achieve studying science? (Which hindered you?)
    f) What does retention mean for you? How would you define it?
        ii. Which teaching and learning practices at secondary school or university have helped you continue (retention) studying science? (Which hindered you?)

6. What does it mean to be a Tongan student studying science?
    a) What is the identity of a Tongan student studying science?
    b) What do you know about Tongan science? Indigenous Tongan science? (Indigenous science knowledge)

7. Are there any questions or comments you would like to make?