Navigating and negotiating borders: Western pre-service teachers' experiences of teaching science in a non-western setting

Abstract

The subculture of science has 'borders' that many find difficult to negotiate. These borders become more complex the further understandings of science are from traditional western perspectives. This paper examines the experiences of two western pre-service teachers' teaching science in a non-western context--the Cook Islands--using data gathered through interviews and learning logs. The lens of 'border crossing' has been used to make sense of these teachers' learning to teach experiences as it provides insights into the ways in which the participants negotiated such crossings over time. This research highlights the importance of recognising the positive interactions and potential for diverse experiences within a cultural context.

Keywords

Border crossing; science education; ways of knowing; pre-service teacher education; non-western contexts

Introduction

Teachers make decisions about what matters for the learners in their science[1] classrooms every day (Hattie, 2003; Author, 2016). They are required to create effective learning environments and build relationships that nurture the ongoing development of science knowledge and skills. Teachers are responsible for ensuring that every student has equal opportunity to learn science in ways that are personally meaningful to them and their lived

[1] This research centres on science education rather than STEM education namely because it was conducted several years ago when this integrated approach to learning and teaching was not yet the focal point of contemporary classroom policies and pedagogies.

experiences (Tytler, 2007). Science teaching is far more than simply delivering curriculum as there are a number of borders that science teachers need to negotiate including the cognitive, disciplinary and/or socio-cultural (Sumadic, 2015). There is no 'one size fits all' approach that works for every student and this makes science teaching challenging. While there is an implicit understanding that this is the case, the reality can be even more challenging when faced with a classroom of students embedded in a culture and context that at times can run counter to scientifically-accepted ways of perceiving the world (Parsons & Carlone, 2013). This paper seeks to explore this tension in the context of a Pacific island state, the Cook Islands.

In further considering this notion of science as being relevant and authentic to everyday experiences, 'border crossing' is an analogy that was adopted by Aikenhead (1996) to acknowledge the act of moving between the everyday subcultures and the subculture of science. This work, while published over two decades ago, remains particularly seminal in the field of science education as a reference point for grappling with non-western (including Indigenous) ways of knowing and connecting with science and science education. In exploring this movement, it is recognised that this process is easier for some than it is for others with these border crossings characterised as smooth, manageable, hazardous and virtually impossible (Phelan, Davidson, & Cao, 1991; Cobern & Aikenhead, 1998). Unsurprisingly, the journeys between these subcultures are more usually experienced by people using western[2] perspectives of science; the belief system in which this knowledge is usually privileged and formalised (Mazzocchi, 2006). This dominance leaves the experience of the virtually impossible journey into the subculture of science to be typically

[2] A lowercase w is used in western and non-western throughout this paper to acknowledge that these two perspectives bring different ways of knowing the world, but is intended to reduce the impact of cultural othering that capitalization may infer (see Bush, 2005). The language of western and non-western is acknowledged as potentially problematic, but it is recognized as one possible lens for interpreting this work and was chosen for its common use in science education research in relation to border crossing experiences.

experienced by people using non-western perspectives to make sense of the science phenomena they encounter in their worlds (Aikenhead, 1996; Banner, 2016).

It is mostly within educational institutions where the difficulties in negotiating these borders crossings are perpetuated as western science is foregrounded as a way of knowing over traditional, indigenous or non-western ways of understanding science (Aikenhead, 2001). Despite the call for 'the demythologising of school science' being discussed in the scholarly literature for over four decades (Smolizc & Nunan, 1975), changes to the ways in which science is taught in schools have been slow to emerge. However, it seems that an openness to integrate western and non-western understandings of science is becoming more commonplace in the learning and teaching of school science (Author, 2018c). For example, the *Australian Curriculum - Science* acknowledges Indigenous ways of knowing science as part of the 'science as a human endeavour' strand (which has equivalence with the widely used construct, the Nature of Science) (ACARA, 2014). This suggests that teaching students about the different ways in which science phenomena are understood and interpreted is valued as part of the formal science curriculum, but it is not necessarily enacted in meaningful or lasting ways due to lack of confidence and professional learning opportunities (Keys, 2003). From here emerges a concern that students and subsequently pre-service teachers are not developing in-depth understandings about the role and value of non-western perspectives of science.

Much research in the field connected with ways of knowing in science has reported on teachers' and teacher educators' experiences of teaching science in culturally diverse settings as well as acknowledging the value of such diversity (e.g. Luft, Bragg, & Peters, 1999; Mensah, 2011). The experiences of students' learning science in culturally diverse contexts have also been documented (Pintrich, 2003). Typically research in this area, the integration of western and non-western perspectives of science knowledge, has focused on

working with teachers and teacher educators to better understand how they make sense of culturally diverse and responsive science teaching and the how they action these understandings in their practices (see Aikenhead & Ogawa, 2007).

In contrast, the research reported on in this paper leverages a unique opportunity to gather data that captures the experiences of pre-service science teachers as they work with students in a cross-cultural context. The significance of this research is that there is the chance to better understand the ways in which the participating pre-service teachers negotiated their own border crossings between the teaching of western ways of understanding science and the more traditional Cook Island Maori ways of understanding science. There is also the opportunity to explore the ways in which these pre-service teachers support their students in their own grappling with these culturally diverse science understandings.

This paper consequently, examines the experiences of two western pre-service teachers' teaching science to students in a non-western setting through the frame of border crossings (Aikenhead, 1996). The setting for this project is the Cook Islands as <<de-identified>> University pre-service teachers have the opportunity annually to complete an optional three-week teaching placement in one of 12 schools located across two islands. The author was the lead academic supporting this program at this time and was able to explore an aspect of this opportunity through a research lens related broadly to their field of study – science education. This documentation provides insights into the ways in which pre-service teachers negotiate the integration of western and non-western science knowledge as well as how they support their students in negotiating the border crossings that are encounter. The teachers' sense of journey is captured in the research questions: - *What are the border crossing experiences of western pre-service teachers' teaching science in a non-western setting,* and *How do they influence their ways of being a science teacher?*

Literature review

Originally the metaphor of 'border crossing' was introduced in 1992 by Giroux (2005) to describe the tensions and issues faced by students with diverse cultural backgrounds as they negotiate dominant (e.g. white, Anglo-Saxon) society. Broadening this construct has enabled the capture of a range of border crossings with a focus on any form of transition from one sub-culture to a new and different one (Giroux, 2005). With this definition in place, the lived experience of learning to teach could be considered as border crossing at numerous sub-cultural levels, such as from student to teacher, pre-service teacher to in-service teacher and university context to classroom setting (Mulholland & Wallace, 2003; Sumadic, 2015). This literature review therefore foregrounds border crossing as a lens for making sense of not only learning to teach, but learning to teach in international contexts and, more specifically, learning to teach western understandings of science in non-western contexts. Working through each of these iterations will help to better position the significance of these border crossings, including their influence on this research, and help to more effectively highlight the complexities in the journeys of the two participants in this study.

Border crossing 1: Learning to teach

The role of professional experience is a critical component of the learning to teach journey (Craven et al., 2014). Pre-service teachers, unsurprisingly, cite their time in schools as a highlight of their initial teacher education program as it provides a practical experience that starts to give them a sense of the teaching profession and their place in it (Author, 2018a). It is also a space that can be fraught with challenges as the realities of the classroom and the role of teacher come into stark contrast (Le Cornu & Ewing, 2008). Many pre-service teachers will experience a sense of familiarity for a context that they are typically not long removed from as a student, which will be countered at times with a disconcerting sense of unfamiliarity as they engage with the space as a teacher (Lortie, 1975; Smagorinsky &

Barnes, 2014). A recent edited collection (Author, 2018b) shares narratives that highlight the impact and influence of professional experience on pre-service teachers as broadly aligning with three key themes: boundary work, relational work and identity work. Deriving from these themes is an underlying message that learning to teach is complex, collegial, and personal, which is reciprocated in other research (e.g. Le Cornu, 2015). While there is no one way to experience this journey, it can be challenging and exhilarating at different points and in diverse ways.

With a focus on boundary work, in keeping with this particular study, the analogy used by Phelan et al. (1991) to characterise the lived experiences of border crossing is a useful way to make sense of the process of learning to teach. Again, while this reference may seem dated, it has become a seminal source and original reference point for a characterisation of how border crossings are experienced. In this first instance, the negotiation of being a pre-service teacher moving between the art (university-based initial teacher education, learner-focused) and the act of learning to teach (guided practical experience in school settings, teacher-orientated) perhaps is best characterised as *smooth* or *manageable*. Smooth relates to the sense that movements between these multiple spaces are congruent with lived experiences and little effort or stress is exerted to successfully navigate back and forth. This might be the case for a pre-service teacher who works part-time with children (e.g. education aide, after-school care) and identifies as being in teacher role. For some, the borders that need to be crossed may not be experienced as straightforward. In this situation, the pre-service teacher may require some external support or personal resourcing to manage an effective negotiation of what to them are quite different worlds. For example, a pre-service teacher educated in the private school system might feel challenged by a government school placement with potentially unfamiliar approaches and ethos (Naylor, 2015).

Border crossing 2: Learning to teach in international contexts

The experience of learning to teach becomes both more complex and rewarding if the journey is shifted into an international setting (Flores, 2017). Increasingly, particularly in the Australian context, initial teacher education providers are enabling their pre-service teachers to complete some of their required professional experience abroad (Authors, 2017). The intention of such opportunities is to equip future teachers with lived experiences of culturally diverse contexts and classrooms (OECD, 2010). This brings an increased intensity when compared with locally-based professional experiences (e.g. within their home context such as Australia in this instance) as pre-service teachers are challenged by issues such as different levels of resourcing, role expectations, language, and required pedagogies (Dantas, 2007; Subban & Clemans, 2017). On the flipside, there tends to be an increased euphoria as a result of classroom experiences resulting in more autonomy, of being valued as colleague, and in successfully overcoming barriers (Kidman, Davies, & Eaton, 2017). An edited collection (Authors, 2017) preceding the one mentioned above, similarly shared narratives of professional experience, but in international contexts. The contributions found that, like in locally-based professional experience, school placements abroad extended learning through a range of new and/or different experiences and impacted significantly on a sense of teacher identity (Authors, 2017). While relational work is undeniably intertwined with this work, it did not emerge as a theme of the collection in the same way that the notion of discomfort, or operating well outside of your comfort zone, did (Authors, 2017).

As a way of making sense of the experience of learning to teach in an international context, Phelan et al. (1991) representations of border crossings are again considered. In this instance, there is very little about these contexts that is congruent with pre-service teachers' experiences on either side of the desk. The transitions that take place in these settings on the surface look and feel familiar, but are experienced as disarmingly different and are therefore recognised as *manageable*, at best, or *hazardous*, more realistically. As detailed above,

movement between different contexts is manageable when pre-service teachers are provided with guidance through external supports or their own personal resources (Mulholland & Wallace, 2003). For example, a pre-service teacher reliant on interactive technologies to implement their learning and teaching activities would need to reassess their pedagogical approach when faced with only a blackboard and chalk. When the transition between contexts is experienced by pre-service teachers as not just different, but diverse from their usual experience it risks becoming hazardous. To weather these challenges, strategies need to be put into place to essentially cope and survive. For example, language barriers faced in the classroom are usually considered as insurmountable initially, but as the pre-service teachers grapple with this they start to consider strategies that would bring about change, such as visual and non-verbal modes of communication (Hartwig, 2017).

Border crossing 3: Learning to teach Western science in a non-Western setting

The learning area of science, in itself, involves a process of border crossing which is signified by a shift from our everyday understandings of the phenomena we experience to more scientifically accepted perspectives (Aikenhead, 1996). For learners, this transition can be experienced as anything from smooth, right through to virtually impossible, particularly when cultural factors are also in play (Brand & Glasson, 2004, McKinley, 2005). Science tends to bring connotations of a western lens for viewing the world and while it might be understood as an international language, this is often to the detriment of the numerous dialects that contribute different, and no less valued, ways of making sense of experienced phenomena (Sumadic, 2015). Experiences of these transitions can become more challenging as a teacher grappling with your own science border crossings alongside students' challenges moving in and between the science sub-culture (with all that encapsulates) and their own (Mulholland & Wallace, 2003). These challenges are amplified for pre-service teachers with science discipline specialisations as they make tentative crossings into the sub-cultures of science and

science education while also navigating the boundaries connected with learning to teach (Snively & Corsiglia, 2001; Mulholland & Wallace, 2003). When such experiences are positioned in an international setting, typically a different cultural context, science pre-service teachers are required to negotiate a number of borders for themselves and their students simultaneously. This brings to the fore the role of culturally responsive pedagogies in helping to navigate these challenges in science education for students and teachers alike (Mhakure & Otulaja, 2017). A pedagogical response like this requires all invested in the educational process (e.g. students, teachers, family, etc.) to consider the learning and teaching conditions required in that context to improve students' experiences in science education (Woods-McConney & McConney, 2014; Boon & Lewthwaite, 2015).

Drawing one final time on Phelan et al. (1991) understandings of border crossing, there is very little about this context that can be considered as familiar (smooth) or simply understood as just different (manageable) from the usual learning to teach journey. Pre-service teachers in this context are faced with a complex and complicated set of borders to navigate as they have an inherent sense of comfort from being indoctrinated into the ways of science through their life experiences and education. This experience can be understood within the construct of multisocialisation, which is the process of socialising into the profession, a new cultural context, and the learning and teaching space (Barton, Hartwig, Joseph, & Podorova, 2017). The process of multisocialisation, however, poses a unique opportunity to challenge this sense of comfort by facing some discomfort and grappling with the tension between lifeworld subcultures of their students and the subculture of science. This discomfort and tension suggests a transitional experience, which is likely to be *hazardous* but has the potential to be *virtually impossible*. As detailed above, hazardous borders can be successfully navigated when coping strategies and survival mechanisms are activated through external support and/or personal resources. Virtually impossible transitions eventuate when

the borders to cross over and the worlds to cross into are highly discordant with day-to-day lived experiences. This incongruence means that pre-service teachers are required to really delve deeply into their psychological and cognitive reserves to find not only a way forward, but a way to persevere in challenging circumstances such as these.

Through the lens of border crossing (Aikenhead, 1996; Giroux, 2005), this literature review started to unravel the complexities inherent in becoming a teacher. The transitions into this world become even more complex and more challenging to navigate when international contexts and non-western connections with science are considered. This paper will now explore the methodologies employed to understand the lived experiences of two western pre-service teachers' teaching science in a non-western context, in this case the Cook Islands, and the impact of this on their journey to becoming a science teacher.

Methodology

Qualitative methodologies are a natural fit for educational research as they reflect the complexities that are inherent in learning and teaching as well as provide an illuminating lens for emergent stories and lived experiences (Atkins & Wallace, 2012). The particular approach adopted for this study was interpretive (Elliot & Timulak, 2005) as it allowed for a sharing of meaning-making practices, while showing how those practices can generate observable outcomes such as themes or recommendations. In this context, an interpretive approach has influenced the research design through the use of more semi-structured techniques to authentically gather the participants' insights and by drawing significantly on the participants' voice to represent their stories. This section identifies the context of and participants in this study and how they were selected before describing the data collection and analytical processes.

Context

The Cook Islands was the setting for this research. It comprises of 15 islands, formed through volcanic activity, that are home to approximately 17,500 people with the majority of this population situated on Rarotonga (around 10,000), the main island in the group. Located north-east of New Zealand and on the same longitude at Hawaii, the Cook Islands are a self-governing country but are in free association with New Zealand, which influences aspects such as citizenship, currency, and education (e.g. curriculum). The main industry for the region is tourism with up to 100,000 visitors a year, but other exports include pearls, marine animals and fruit. Polynesian people from nearby Tahiti are recorded as moving to the Cook Islands in the 6th century with visits and sightings from the Spanish and British over the 16th to 19th centuries. In 1888, the country was officially identified as a British protectorate. As a result, and perpetuated by the significant tourist numbers, English is the official language alongside Cook Island Maori. There are, however, a number of dialects associated with the different islands. In schools, students are instructed in Cook Island Maori up to Year 3 (around 8 years of age) before the language of instruction switches to English. The New Zealand curriculum is applied to all levels of schooling, although since this research was conducted a Cook Islands Curriculum Framework has been developed and introduced to ensure a more context-specific approach to learning and teaching.

Participants and their selection

Two participants took part in this research study – Sophie and Ness (pseudonyms). Of a cohort of 24 pre-service teachers undertaking professional experience in the Cook Islands at the time of this study, they were the only participants with science specialisations, which was a key selection criteria due to the nature of this research. In this instance, purposeful sampling was indicated as it is an effective approach when only a limited number of people can contribute as primary data sources due to the nature of research aims and questions (Suri, 2011). Categorised within purposeful sampling techniques as critical cases (Palinkas

et al., 2015), which focuses on exploring and explaining the phenomena of interest, both Sophie and Ness accepted an invitation to contribute to this research.

Sophie brought significant experience in nursing to her developing teaching practice. She had worked as a nurse and in nurse recruitment for United Kingdom hospitals for nearly 20 years. As a mature-age student with this background, she brought a significant skill set for problem solving, working in challenging situations, and interacting with a wide range of people. During this study Sophie was in her final semester of a Graduate Diploma in Education (Secondary) specialising in general science and health. She was part of the final cohort of students to complete a one-year initial teacher education course at <<de-identified>> University. In contrast, Ness had only commenced her studies and was part of the first offering of a two-year education qualification, a Master of Teaching (Secondary). Her background included working as a laboratory-based scientist in the area of nutrition specifically; an area which had seen her employed in both Australia and the United Kingdom over the past five years. Like Sophie, she was a mature-age student with a range of life and work experiences that informed her science teaching practices. Ness was specialising in general science and biology education.

The professional experience in the Cook Islands, a total of 15 days, was to be Sophie's final teaching placement and contributed to her required 50 days of supervised practice. Whereas for Ness, this was her second of four placement blocks to be completed over the course of her qualification to make up her required 60 days of supervised teaching. Up to this point, both participants had completed their professional experience in large (1200+ students), urban secondary schools.

Data collection

Two key data collection tools informed this research: pre- and post-semi-structured interviews (total of four) and reflective learning logs (total of six). Interviews tend to be a

more naturalistic data collection tool, which assisted in broadening the scope of understanding the phenomena under investigation (Alshenqeeti, 2014). This data set was useful as it allowed the researcher to discuss with each participant their perceptions and expectations about teaching science in the Cook Islands (a non-western setting) before their teaching placement and then to discuss their experiences and learning following the placement. With this purpose in mind, a semi-structured interview format was a more functional way of collecting data as it enabled responsiveness in the questioning and opportunities for elaborations from the participant (Gill, Stewart, Treasure & Chadwick, 2008). The interviewing approach could be deemed semi-structured as there was a set of key questions to explore, but there was flexibility to further probe the participants' responses. Each interview was about 30 minutes in length, was conducted by a research assistant on-campus at a time convenient to the participant, and was audio-recorded before being transcribed. To ensure the participants' views were accurately captured in the transcripts, they were shared with Ness and Sophie for their validation.

Learning logs have similar qualities to a diary in that they enable a record of thinking and behavior to be captured over time. Their point of difference, however, is that the more reflexive approach attempts to not only captured changed thinking, but what is influencing that change and how this then subsequently plays out in practice (Friesner & Hart, 2005). This approach to reflection prompts a deep level of introspection and, in this case, how it might connect with practice. Sophie and Ness kept a reflective learning log during their three-week school placement with each providing a weekly response, which they emailed to the research assistant working on this project at the end of each week. This resulted in the participants' producing three learning logs each over their three week professional experience in the Cook Islands. They were provided with some open-ended questions to prompt and scaffold their thinking (e.g. what did you notice in the science lessons this week, what impact

did this have (or not) on your science teaching approach, etc.) and responses ranged from one to two pages in length.

While the author was present in the Cook Islands during this experience, she distanced herself from the data collection process. This enabled her to support the two pre-service teachers, along with the entire cohort, in her role as program lead in a way that would not impinge on the research or compromise the relationships. This was important as capturing the participants' honest insights and lived experiences, not filtered by the author or as a response to what the author may have wanted to hear or read, was critical to really understanding the impact of this time and place on their learning to be science teachers' journey.

Data analysis

In an interpretive study such as this, the intent was to allow for the emergence of rich, 'thick' descriptions of the experience (Merriam, 1998). The focus on emergent interpretations, rather than on existing theories, is a legitimate approach to data analysis that is based in grounded theoretical understandings of research (Corbin & Strauss, 2008). To enable this, the two data sets – the interview transcripts and written responses in the learning logs – were scrutinised individually using an inductive approach. This essentially involved the author engaging in four steps:

1. Reading the transcripts/responses and using note taking to identify key ideas in direct response to the research question;
2. Re-reading the transcripts/responses to articulate the key themes that would encapsulate these ideas;
3. Re-engaging with the transcripts/responses to locate quotes that would exemplify these themes; and

4. Scanning the transcripts/responses a final time in search of disconfirming evidence that could be used in juxtaposition to the emergent themes.

From this process, the findings emerged in a way that reflects the before, during and after nature of this study. Each part of this journey further unpacked Ness and Sophie's experiences of being western pre-service science teachers in a non-western setting. The result (as presented in the following section) is not the provision of fine-grain insights, but instead a broad-brush perspective of the key factors shaping and challenging the participants' thinking about science education in this particular context. Their voices have certainly shaped the categorisation and labelling of these themes, but the author has represented these insights in ways that capture the bigger picture across the experience as a whole.

Findings

The findings for this study are presented in three parts. Part 1 is drawn from the initial semi-structured interviews with Ness and Sophie and has been crafted into a narrative to represent their sentiments prior to their professional experience in the Cook Islands. Part 2 is shaped by Ness and Sophie's learning logs, which detail what they were noticing or learning about as they taught science in local secondary school classrooms. Part 3 reconnects with Ness and Sophie following their school placement in the Cook Islands using semi-structured interviews to learn more about their learning to teach science experiences. While a study of this nature could be appropriately presented as two discrete case studies, the richness of this work – particularly in capturing border crossings – is best articulated when the different experiences of Ness and Sophie are in juxtaposition over time.

Border crossing 1: Prior to professional experience

When the first interview was conducted Ness had already connected with her mentor teacher in the Cook Islands. She has been made aware that she would be teaching genetics to senior

secondary students, something she had done in her previous placement, along with electricity to the middle years students, which was outside her comfort zone. In considering how she would approach the teaching of science in this setting, relevance emerged strongly as a key consideration for Ness. For example, in grappling with electricity and how to find possible connections with her students' lives, she "started looking at what kind of generators they have over there and that kind of thing to know what they have got to relate back to the kids".

Ness had also prepared herself by looking at the Cook Islands science curriculum documents and found "it is very focused on … sharing the natural world" as well as having "a major focus on culture, sports and music". She had an awareness of drawing on the context in informing her practice, but with no clear way forward in terms of how to approach this other than not trying to replicate what she did in previous settings. "I don't think I want to take my laptop because I want to try and be able to do it with what's there and how they teach there". Ness did, however, trust in being supported by the community and her mentor in the process of fitting in. "Polynesian culture is well known as being so friendly and welcoming it won't be too much of an issue". Her sense of learning to be a science teacher in the Cook Islands focused on cultural context and connections, but was perhaps underpinned by some naïve conceptions of what this actually means and will look like.

Emerging from the initial interview with Sophie was her conceptions of science and science teaching as content focused and centred on her perceived level of conceptual knowledge. "I taught what I could consider my almost worse nightmare, I had to teach space which I had absolutely no idea about … and felt exposed for my fraudulent amount of information". Her thinking around how to approach her time in Cook Islands schools, however, revealed the importance she placed on knowing your students in any context. "I found that's been a challenge already to understand how to pitch my language to any audience, so I don't know whether I will expect the Cook Islands will be any different".

Although, Sophie anticipated "that the influence of culture [would be] more pervasive than I think it is in Western cultures" with an expectation that "the Cook Island way of knowing is heavily informed by their surroundings, cultural background and way of living". Her past professional experiences equally challenged her in terms of expectations and created in her an awareness of understanding the context as well as turning to her mentor for guidance about what is appropriate.

> *What I want to do right is teach in respectful ways. I think that will be just as hard for me in a way as teaching sex education in a western Catholic school when I'm not from a very religious background.*

Sophie's approach to tackle this experience with an open mind is guided by wanting to present science accurately, but in ways that will be authentic to the students' lived experiences. "I'm really conscious about how I'm going to be truthful to them and make it meaningful for them because I'd hate to think that I will walk in there with grandiose expectations that I won't be able to fulfil".

Border crossing 2: During professional experience

Drawing from her learning log entries, Ness' first impressions connected with the level of resourcing she could draw upon to support her science teaching. "I was surprised at how well resourced the school is for science. Although the resources are limited, they have more than I was expecting". She needed to become reliant on less visual aids, particular those that are technology-driven, and spread materials further with large class sizes. While teaching electricity became easier for Ness than anticipated – "there are just less electrical appliances and computers around … students are still exposed to electricity in their everyday lives" – genetics was noticeably more challenging. "[Genetics] is a difficult topic … the limited cultural variation in the Cooks compared to an [urban Australian] classroom makes it more difficult to talk about genetic differences". She did acknowledge that her students are

exposed to cultural difference through movies and tourists, but not on an everyday basis. While Ness was mindful of using "simple language" to support student learning in science in her usual Australian context, the role of language and the "need to make adjustments for students learning science" became more apparent as the majority of students in the Cook Islands speak English as an additional language (after Cook Island Maori). The relationship between science understanding and English language skills was noted by Ness as "problematic". Finally, Ness' expectation that science teaching would be informed by contextual factors fell short. "There is not as much focus in the science around them". This is namely due to science learning and teaching, particularly for senior students, being informed by the New Zealand curriculum. Ness attended a professional development workshop during her placement experience were local science teachers were prioritising the creation of a Cook Islands science subject "to be commonly taught across all the islands to promote a focus on sciences relevant to the islands". This initiative was creating a lot of energy, but struck Ness as surprising as she "thought it would be the main difference in the teaching of science in the Cooks".

Completing her placement across two islands and secondary schools added an additional level of insights to Sophie's learning logs. Her first school was significantly under-resourced – "students rarely had pencils let alone calculators or text books" – and experiencing challenges with staff retention – "the science teacher I observed … was the school's 7th science teacher that year", which impacted on science learning and teaching. "Looking at the students' exam papers it was clear that these students had massive gaps in understanding the science concepts even at a basic general knowledge level". This was not as much of an issue in her second school, but Sophie was still required to be resourceful with the experience highlighting her dependence on information and communication technology (ICT) tools in the Australian context. "Taking all of this away meant that I was drawing more

on my own knowledge, the resources of fellow teachers, and more basic pedagogical approaches". A common factor across both schools impacting Sophie's approach to science teaching was the students' level of English. "I was aware really quickly that many of the students' primary language is Cook Islands Maori and that they struggle with basic English skills let alone understanding the complicated language of science". This lead her to slow down the pace of the lesson, speak more slowly and spend considerable time checking for understanding. One significant challenge was working with classes where the language of instruction is usually Cook Islands Maori, but all assessment was completed in English as a response to using the New Zealand curriculum. A contextual feature of Sophie's second school was the impact of religion on her science teaching. After attending an evening bible study session, which most students attended a few nights a week, she become aware of the impact on teaching genetics. "This was a light bulb moment for me … students were coming to class to learn one theory that would possibly be totally refuted by their religious understandings". Sophie's school experiences changed the way she viewed what matters in teaching science.

> *I was less stressed about the content or making flashy worksheets and PowerPoint presentations. As such, I was able to focus more on the students' needs and trying to cater for the English as a Second Language students and more specifically try to find ways to accommodate their cultural/religious views into my lessons*.

Border crossing 3: After the professional experience

In her follow-up interview, Ness stated that, "To be honest, I didn't really notice that great a difference when I was actually in the classroom". For Ness, her experiences of teaching science in the Cook Islands were not markedly different to her previous school-based experiences. She surmised two possible explanations for this. Firstly, Ness considered the impact of her mentor teacher, who was educated as a teacher in New Zealand and identified

as pakeha (non-Maori), on this perceived similarity with the Australian context. “I was with a teacher who was western trained and she’s only two years out of her own teacher training, so her methods of teaching science were similar to how I would teach”. Secondly, the school Ness was at was the only institution equipped in the Cook Islands to support students to complete their final years of schooling and transition into tertiary study. “Look the college that I was at was the main one for the Cook Islands, but the students go there if they want to do their final years of study to try to get into further study”.

In this context, Ness didn’t notice that level of English language proficiency was an issue and was perhaps not dissimilar to the experiences of a culturally diverse school setting in urban Australia. She did hear other teachers, however, comment of the sizeable gap in language level between students from Rarotonga and those from the outer islands, which was attributed to a lack of exposure to English through stimuli like “tourists and movies” outside of the main island. Ness was surprised that science teaching approaches did not draw upon or connect with the local context, particularly in relation to the environment, more often. This was set to change with science teachers across the islands driving the creation of a Cook Islands science curriculum. Ness recognised that it was interested and energetic teachers driving this change along with supportive leadership from the Ministry of Education.

In contrast, in Sophie’s follow up interview, the role of language emerged as having a significant impact on her experience of learning to teach science. “Probably my biggest challenge was just the ESL part of it” and then subsequently “being able to assess the climate of my classroom and engage [the students]”. Not only did Sophie have to modify her delivery – “they just had no idea what I was saying if I did speak quickly” – but also engage in explicit teaching to bridge the gap between the language of instruction and the language of assessment – “[they] didn’t understand the English words … like explain, describe or communicate or the typical words that were used in their assessments”. Sophie noted that

attempts to make connections with local cultural practices did support science understandings, but there were many missed opportunities to make stronger links to the environment (e.g. marine sciences) – "I think that would have been a really powerful influence had they been able to do that" - and lived experiences (e.g. agricultural practices, music) - "there just seemed to be a disconnect between [their lives] and their schooling".

Another challenge that Sophie continued to face in teaching science, particularly in her second school, was the influence of religion and not just in teaching evolution, but with conceptual areas such as space (e.g. "I just had to accept his answer that beyond our universe was God because that was his real belief"). This was not a consideration in her previous teaching experiences and she realised that she needed to accommodate these beliefs in ways she wasn't expecting. In facing these challenges, Sophie had to recognise her "anxiety about teaching science" and what emerged was a more in-depth understanding of herself as a teacher along with what she was capable of in challenging circumstances.

> *I think I found through the Cook Islands experience was that I knew more about being teacher than I thought and knew more about how to put it together to make it meaningful and that it didn't matter if I didn't know the content, that was not my fear anymore, the content would come.*

Discussion

In keeping with the structure used in other parts of this paper, this section will explore the lived border crossing experiences of two Western pre-service teachers' teaching science in a non-Western setting. It will also examine the influence of this experience on their ways of being a science teacher before, during and after their professional experience in the Cook Islands. Rather than labelling each section as such, this experience is made sense of through the types of border crossings Ness and Sophie navigated and negotiated over time. These

border crossings can be characterised as being pedagogically-, contextually- and culturally-focused with each being explored in detail. In considering the emergent themes within each of these border crossings, links will be made to Phelan et al. (1991) analogy – border crossings as smooth, manageable, hazardous or virtually impossible - to make further sense of Ness and Sophie's border crossing experiences in this context.

Pedagogical border crossings: Content and resources

Not unlike other pre-service secondary teachers, content was at the forefront of both Ness and Sophie's mind as they prepared for their teaching experience in the Cook Islands (Marlow & Inmen, 2002). Content tends to take on the role of 'security blanket' of sorts when learning to teach particularly in a secondary context, namely because it is an aspect of the work of a teacher that is generally familiar and more easily managed than pedagogical considerations (Hudson, 2014). In secondary settings, conceptual understandings and specialisations are often what sets teachers apart (Shulman, 2005), but this focus can run the risk of over-estimating the role of content in terms of what really matters in relation to having a holistic understanding of the work of a teacher (Shulman, 1987).

Similarly, context and culture were also both at the forefront of Ness and Sophie's thoughts as they anticipated what they might discover in Cook Islands classrooms. These constructs were filtered through the lens of relevance and authenticity as they considered the approaches they might interweave into their science learning and teaching practices to appropriately engage Cook Island students. Again, these insights are not surprising findings for pre-service science teachers (Best, 2017). While a connection with pedagogy is more evident, these insights were still very much linked to how content can be enacted in ways that are relevant and authentic in terms of the particular science conceptual area being explored rather than applying this understanding to the learning of science practices and skills (e.g. engaging with science in the ways that scientists would) (Hudson, 2014).

Not dissimilar to preparing for locally-based professional experience, Ness and Sophie were envisaging what to expect based on their past school placements as well as the preparation they had in the lead up to heading abroad (e.g. briefing sessions, communicating with their mentor, etc.). Whether this provided them with a realistic expectation or not of what lay ahead, they seemed to be navigating the lead up to this transition from the familiar to unfamiliar in a way that was *manageable* and *well managed* (Phelan et al., 1991). It is interesting to consider the role of the unknown in this instance and whether this leads to naïve sense of calm because of the challenge in predicting what might actually occur during this three week experience.

Contextual border crossings: Context and school

What quickly emerged as Ness and Sophie start their teaching experiences in different schools is the impact of context in terms of not only the cultural components connected with being in the Cook Islands, but the influence of a variety of school-level factors. The significant impact of contextual features at a micro rather than macro level is somewhat surprising as it starts to highlight that it is not only cultural influences that make a difference in relation to educational outcomes (Tarhini, 2013).

In Ness' case, her school was the only one in the island group that prepared students for a university pathway by having a Year 13 stream, was well resourced, and employed teachers undertook initial teacher education in New Zealand. In contrast, Sophie's school had issues retaining staff and was very much under resourced. Emerging here is a powerful illustration of the impact of resourcing – whether it be about people or material goods – on learning and teaching (Subban & Clemans, 2017). While models for equitable school funding are being discussed in locations like Australia (see Buckingham, 2011), Westernised countries are not alone in feeling the effects of inequitable funding models (e.g. Carnoy & Samoff, 1990) and, in this instance, the impact on Ness and Sophie's experiences learning to

teach science is evident. During this stage, the role of language and its impact on science learning and teaching influenced the practices of both pre-service teachers. The disconnect between the language of instruction in schools (English) and the language spoken at home (Cook Island Maori) has an incredible impact on learning (Piper, Zuilkowski, Kwayumba, & Oyanga, 2018), which is perhaps even more evident in an area like science with its specific terminologies (van Laere, Aesaert, & van Braak, 2014). This disconnect is experienced, but not necessarily congruent, within both western and non-western approaches to science knowledge (Robinson, 2005; Sallabank, 2013).

Ness and Sophie's lived experiences of learning to teach science start to diverge during this stage of their journey with a connection emerging around the level of familiarity or difference experienced in the classroom and school compared with past education experiences. Drawing on Phelan et al. (1991) analogy, Ness' time in the classroom was being experienced as *manageable*, which could be attributed to the similarities between the Cook Islands school setting she found herself in compared with an Australian educational context. This experience was not requiring her to teach science in a significantly different way than she would in any culturally diverse Australian classroom. Sophie's experience of learning to teach science in Cook Islands' schools, however, could be more realistically characterised as *hazardous* due to the distinct disconnect with her past experiences in Australian classrooms. She was being challenged to find ways to teach that were not, unfortunately, necessarily about being culturally appropriate or responsive, but were tailored to meet the linguistic needs of her students and respond to the level of resourcing that was available.

Cultural border crossings: Language and religion

In looking back, Ness identified her experiences of teaching science in the Cook Islands as not being distinctly different to teaching science in an Australian setting, which she directly attributed to the nature and context of the school she was placed at. Throughout this

experience, she continually *managed* the borders she faced with few issues and perhaps at times even experienced this opportunity as *smooth* (Phelan et al, 1991). While she did adopt strategies to support the science learning of students with English as an additional language or dialect, perhaps the bigger surprise for Ness was the wider community context not being a rich source to draw on to enhance students' learning of science. This, however, might be accounted for through the use of the New Zealand curriculum as well as the significant number of teachers at this particular school who were not from the Cook Islands with both not affording ways to draw on local environment and knowledge (see Kalolo (2015) for relevant commentary from an African context). It is interesting to consider the impact of this experience on Ness' learning to be a science teacher. If the experience was so similar to a local Australian context, what does she take away from and what becomes the point of going abroad? It is interesting to consider that a certain level of discomfort within an experience can often impact more significant on learning (Faulkner, Keary, & Drew, 2017).

It is challenging not to view Sophie's experiences of teaching science as completely different to Ness' and hard to even conceive at times that they were in schools positioned within the same education system. Her lived experience across two schools and islands certainly maintained a *hazardous* edge, perhaps seemingly *virtually impossible* at times, as Sophie navigated and negotiated her way through the system, though towards the end of the teaching placement she certainly was finding herself able to move into a more *manageable* space (Phelan et al., 1991). English language abilities and the role of religion emerged as the biggest challenges she experienced in grappling to teach science. Finding ways to communicate science knowledge in English at an appropriate level for the students along with navigating the impact of religion on her students' ways of knowing science were the two key aspects that Sophie found herself spending a significant amount of time and energy on. Her experiences raise some interesting questions around the interconnected nature, in the

Cook Islands context at least, of culture, language and religion (Coburn, 1996; Ferguson, 2014). Should these influences be separated? Can language and religion be components of culture? Exploring the notion of what culture is and means in any particular context becomes an important consideration when entering a new setting or cultural interface (Hartley, 1995; Nakata, 2007).

Conclusions

This paper aimed to answer the questions - What are the border crossing experiences of western pre-service teachers' teaching science in a non-western setting and How do they influence their ways of being a science teacher? An investigation of Ness and Sophie's journeys of learning to teach science in secondary schools in the Cook Islands, confirmed that a 'one size fits all' approach to learning and teaching is not appropriate in any context. Their insights highlight that the borders they needed to navigate in teaching western perspectives of science in a non-westernised setting were experienced as convergent and at times divergent, but also ways that might not have been easily anticipated at the outset of this project.

Emerging from this work is a realisation of the layers of complexity that exist in these contexts. Each school had a variety of contextual factors and pressures influencing and impacting what they do in their science classrooms. Sophie's experience, in particular, posed her a number of challenging borders to negotiate because of the range of factors and pressures at play in the school communities she was working within. In comparison, Ness' experience was aligned more closely with the structures and systems she was familiar with from the Australian context. While pedagogical considerations remained an area to grapple with in terms of their practice for both participants, there was a marked shift away from viewing the work of a secondary science teacher through a conceptual lens. Emerging at this point is a growing awareness around the importance of equipping pre-service teachers, such

as Ness and Sophie, with the knowledge and skills required to enact culturally-responsive pedagogies in ways that will matter for their context. For this work, border crossing became a useful frame for naming and unpacking these different lived experiences and foregrounding what these differences were along with the ways they stared to shape the participants' science teaching practices and science teacher identities.

This research highlights that as influential as broader cultural aspects were on learning science in this instance, language and religion played the more prominent roles in terms of how science was understood and engaged with by Cook Island students. These factors become more apparent over time and signalled a shift for both Ness and Sophie from concern around issues such as content knowledge and resourcing to focusing on pedagogy and their own emerging teacher identities. While initial teacher education programs in the Australian context are required to include coursework focused on cultural awareness and responsiveness, a question remains around how prepared pre-service teachers are to internalise and apply this knowledge to complex cultural issues, particularly when intertwined with multi-faith societies and specific learning areas (e.g. science). This work, and unanswered question, signals to both science teachers and teacher educators alike that we need to be attuned to this complexity and adjust what we do – or support our pre-service teachers to enact – in the classroom to meet the science learning needs of all students appropriately, mindfully and purposefully. This approach to science education signals that rather than valuing one tradition or knowledge base over another (e.g. western ways of knowing science) the ability to simultaneously refer to two or more traditions or frameworks will lead to richer ways of understanding and connecting with science.

References

Aikenhead, G.S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27,* 1-52.

Aikenhead, G.S. (2001). Worldviews, students, science teachers, school science: Where to next? *Studies in Science Education, 36*(1), 135-141.

Aikenhead, G.S., & Ogawa, M. (2007). Indigenous knowledge and science revisited. *Cultural Studies of Science Education, 2,* 539-620.

Alshenqeeti, H. (2014). Interviewing as a data collection method: A critical review. *English Linguistics Research, 3*(1), 39-45.

Atkins, L. & Wallace, S. (2012). *Qualitative research in education.* London, UK.: SAGE Publications.

Australian Curriculum, Assessment and Reporting Authority [ACARA]. (2014) *Foundation to year 10 curriculum: Science*. Retrieved from https://www.australiancurriculum.edu.au/f-10-curriculum/science/

Author, 2016

Author, 2017

Author, 2018a

Author, 2018b

Author, 2018c

Banner, I. (2016). Valuing differences in students' culture and experience in school science lessons. *Cultural Studies of Science Education, 11*(4), 1071-1079.

Barton, Hartwig, Joseph & Podorova (2017). Practicum for international students in teacher education programmes: An investigation of three university sites through multisocialisation, interculturalisation and reflection. In G. M. Barton & K. Hartwig (Eds.), *Professional Learning for International Students: Exploring Theory and Practice* (pp. 129-146). Switzerland: Springer.

Best, M. (2017). Transforming pre-service teachers' beliefs and understandings about design and technologies. *Australian Journal of Teacher Education*, *42*(7).

Boon, H.J., & Lewthwaite, B.E. (2015). *Signatures of quality teaching for Indigenous students.* Paper presented at the Australian Association of Research in Education (AARE), 29 Nov–2nd Dec., University of Notre Dame, Fremantle, Western Australia.

Brand, B.R. & Glasson, G.E. (2004). Crossing cultural borders into science teaching: Early life experiences, racial and ethnic identities, and beliefs about diversity. *Journal of Research in Science Teaching*, *41*(2), 119-141.

Buckingham, J. (2011). *Issue analysis: School funding, choice and equity.* Retrieved from http://www.cis.org.au/app/uploads/2015/07/ia126.pdf

Bush, C. (2005). The other of the other?: Cultural studies, theory and the location of the modernist signifier. *Comparative Literature Studies*, *42*(2), 162-180.

Carnoy, M., & Samoff, J. (1990). *Education and social transition in the third world.* Princeton, NJ: Princeton University Press.

Craven, G., Beswick, K., Fleming, J., Fletcher, T., Green, M., Jensen, B., Leinonen, E., Rickards, F. (2014). *Action now : classroom ready teachers*. [Canberra] : Australia. Teacher Education Ministerial Advisory Group.

Cobern, W.W. (1996). *Traditional Culture and Science Education in Africa: Merely Language Games?* Paper presented at the Tokyo Institute of Technology in Meguro-ku, Tokyo, Japan on 28 September 1996.

Cobern, W.W., & Aikenhead, G. (1998). Cultural aspects of learning science. In B.J. Fraser & K.G. Tobin (Eds.). *The International Handbook of Science Education* (pp. 39-52). Great Britain: Kluwer Academic Publishers.

Corbin, J.M., & Strauss, A.L. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Dantas, M.L. (2007). Building teacher competency to work with diverse learners in the context of international education. *Teacher Education Quarterly, 34*(1), 75-94.

Elliott, R., & Timulak, L. (2005). *Descriptive and interpretive approaches to qualitative research.* In J. Miles and P. Gilbert (Eds.). A Handbook of Research Methods for Clinical and Health Psychology (pp. 147-159). New York, NY: Oxford University Press.

Faulkner, J., Keary, A., & Drew, J. (2017). Resilience, global threat, and international professional experience. In A. Fitzgerald, G. Parr & J. Williams (eds.). *Narrative of Learning through International Professional Experience* (pp. 153-168). Singapore: Springer.

Ferguson, J. (2004). *Is there a place for religion in the science classroom?* Retrieved from https://theconversation.com/is-there-a-place-for-religion-in-the-science-classroom-26368

Flores, M.A. (2017). Teaching and developing as a teacher in contradictory times. *Teachers and Teaching, 23*(2), 123-126.

Friesner, T., & Hart, M. (2005). Learning logs: Assessment or research method. *The Electronic Journal of Business Research Methodology, 3*(2), 117-122.

Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal, 204*, 291-295.

Giroux, H. (2005). *Border crossing: Cultural workers and the politics of education* (2nd ed.). New York, NY: Routledge.

Hartley, R. (1995). *Families and cultural diversity in Australia.* Retrieved from https://aifs.gov.au/publications/families-and-cultural-diversity-australia/1-families-values-and-change-setting-scene

Hartwig, K. (2017). The study abroad programme: Experience and benefits. In G. M. Barton & K. Hartwig (Eds.), *Professional Learning for International Students: Exploring Theory and Practice* (pp. 225-237). Switzerland: Springer.

Hattie, J.A.C. (2003, October). *Teachers make a difference: What is the research evidence?* Paper presented at the Building Teacher Quality: What does the research tell us ACER Research Conference, Melbourne, Australia. Retrieved from http://research.acer.edu.au/research_conference_2003/4/

Hudson, P.B. (2014). Understanding preservice teachers' development of pedagogical knowledge practices when co-teaching primary science to peers. *Journal of Science and Mathematics in Southeast Asia*, *37*(1), 44-66.

Keys, P.M. (2003). *Primary and secondary teachers shaping the science curriculum: The influence of teacher knowledge.* Retrieved from https://eprints.qut.edu.au/15920/1/Philip_Keys_Thesis.pdf

Kidman, G., Davies, Z., & Eaton, C. (2017). Acknowledging and learning from discomfort: The learners' perspective. In A. Fitzgerald, G. Parr & J. Williams (eds.). *Narrative of Learning through International Professional Experience* (pp. 139-152). Singapore: Springer.

Le Cornu, R. (2015). *Key components of effective professional experience in initial teacher education in Australia [Report]*. Australian Institute for Teaching and School Leadership, Melbourne.

Le Cornu, R., & Ewing, R. (2008). Reconceptualising professional experiences in pre-service teacher education … reconstructing the past to embrace the future. *Teaching and Teacher Education, 24,* 1799-1812.

Lortie, D.C. (1975). *Schoolteacher*. Chicago, IL: University of Chicago Press.

Luft, J.A., Bragg, J., & Peters, C. (1999). Learning to teach in a diverse setting: A case study of a multicultural science education enthusiast. *Science Education, 83,* 527-543.

Marlow, L., & Inmen, D. (2002). What pre-service teacher professional development must become in the 21st century. *Journal of Thought, 37*(3), 45-51.

Mazzocchi, F. (2006). Western science and traditional knowledge: Despite their variations, different forms of knowledge can learn from each other. *EMBO Reports, 7,* 463-466.

McKinley, E. (2005). Locating the global: Culture, language and science education for indigenous students. *International Journal of Science Education, 27*(2), 227-241.

Mensah, F.M. (2011). A case for culturally relevant teaching in science education and lessons learned for teacher education. *The Journal of Negra Education, 80*(3), 296-309.

Merriam, S.B. (1998). *Case study research in education: A qualitative approach* (2nd ed.). San Francisco: Jossey-Bass Publishers.

Mulholland, J., & Wallace, J. (2003). Crossing borders: Learning and teaching primary science in the pre-service to in-service transition. *International Journal of Science Education, 25*(7), 879-898.

Nakata, M. (2007). *the* cultural interface. *The Australian Journal of Indigenous Education, 36* (S1), 7-14.

Naylor, D. (2015). Learning to teach: What pre-service teachers report. Retrieved from http://ro.ecu.edu.au/theses/1626

Organisation for Economic Cooperation and Development. [OECD], (2010). *Education at a glance 2010: OECD indicators.* Retrieved from http://www.oecd.org/education/skills-beyond-school/educationataglance2010oecdindicators.htm.

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and policy in mental health and mental health services, 42*(5), 533-544.

Parsons, E.C., & Carlone, H.B. (2013). Culture and science education in the 21st century: Extending and making the cultural box more inclusive. *Journal of Research in Science Teaching, 50*(1), 1-11.

Phelan, P., Davidson, A., & Cao, H. (1991). Students' multiple worlds: Negotiating the boundaries of family, peer, and school cultures. *Anthropology and Education Quarterly, 22,* 224-250.

Pintrich, P.R. (2003). A Motivational Science Perspective on the Role of Student Motivation in Learning and Teaching Contexts. Journal of Educational Psychology, 95, 667-686.

Piper, B., Zuilkowski, S., Kwayumba, D., & Oynaga, A. (2018). Examining the secondary effects of mother-tongue literacy instruction in Kenya: Impacts on student learning in English, Kiswahili, and mathematics. *International Journal of Educational Development, 59*(March), 110-127.

Robinson, P.J. (2005). Teaching key vocabulary in geography and science classrooms: An analysis of teachers' practice with particular reference to EAL pupils' learning. *Language and Education, 19*(5), 428-445.

Sallabank, J. (2013). *The sociolinguistic situation in the Cook Islands.* Retrieved from https://eprints.soas.ac.uk/21246/1/The%20sociolinguistic%20situation%20in%20the%20Cook%20Islandsc.pdf

Shulman, L.S. (1987). Knowledge and teaching: Foundations of new reform. *Harvard Educational Review, 57*(1), 1-23.

Shulman, L.S. (2005). Signature pedagogies in the professions. *Daedalus, 134*(3), 52-59.

Smagorinsky, P. & Barnes, M.E. (2014). Revisiting and revising the apprenticeship of observation. *Teacher Education Quarterley, Fall,* 29-51.

Smolizc, J.J., & Nunan, E.E. (1975). The philosophical and sociological foundations of science education: The demythologizing of school science. *Studies in Science Education, 2,* 101-143.

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education, 85*, 6-34.

Subban, P. & Clemans, A. (2017). Outside in: Learning from an international professional experience program. In A. Fitzgerald, G. Parr & J. Williams (eds.). *Narrative of Learning through International Professional Experience* (pp. 111-124). Singapore: Springer.

Sumadic, K.S. (2015). Border crossings in a multicultural classroom: Science among the Indigenous learners. *Anthropology, 3*(1), 149-154.

Suri, H. (2011). Purposeful sampling in qualitative research synthesis. *Qualitative Research Journal, 11*(2), 63-75.

Tarhini, A. (2013). *The effects of cultural dimensions and demographic characteristics on e-learning acceptance.* Retrieved from https://arxiv.org/pdf/1607.01492.pdf

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future.* Melbourne: Australian Council for Educational Research.

Van Laere, E., Aesaert, K, & van Braak, J. (2014). The role of students' home language in science achievement: A multilevel approach. *International Journal of Sciene Education, 36*(16), 2772-2794.

Woods-McConney, A. & McConney, A. (2014). *Indigenous Student Success in Science.* Perth: Murdoch University, School of Education.