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**CULTURALLY RESPONSIVE TEACHER ACTIONS TO SUPPORT PĀSIFIKA
STUDENTS IN MATHEMATICAL DISCOURSE**

A thesis presented in partial fulfilment of the requirements for the degree of
Master of Education at Massey University, Palmerston North, New Zealand

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ABSTRACT

This study examines culturally responsive teaching to support a group of Pāsifika students aged 11-13 years old in mathematical discourse. It builds on previous work which has advocated culturally responsive practices where students learn mathematics through collaborative interaction that fosters greater student participation, engagement, and potentially better achievement in mathematics. In this study, the teacher's actions drew on Pāsifika cultural practices and the value of the family, respect, and collectivism. This was significant in the establishment of social and mathematical behaviours which were important in supporting the development of productive mathematical discourse. In addition, the communicative and participation structures within the classroom that lead to mathematics learning are also considered.

This study was situated in an inquiry classroom. A socio-cultural perspective provided the framework for analysing the classroom context. A case study approach drawing on a qualitative design was implemented. Data was collected through teacher and student interviews, classroom audio and video-recorded observations, and students' written work. Detailed retrospective analysis of the data was undertaken to develop the findings of this classroom case study.

Significant changes were revealed in the shifts of student discourse from long silences and hesitation to asking valid questions and developing mathematical justification with appropriate language and specific terms. The explicit instructional practices developed and implemented by the teacher fostered greater collaborative communication and interaction between group members and this was important in how they made mathematical meaning. The findings provide insights into the multi-dimensional ways that teachers can draw on students' cultural strengths, values, and practices as invaluable resources which potentially will make a difference in students' mathematical learning.

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CHAPTER ONE – INTRODUCTION

1.1 INTRODUCTION

This chapter provides the background context to the study. This context takes into account the international and national calls for changes to how mathematics is taught to students of diverse backgrounds (Bills & Hunter, 2015; Civil, 2014; Johnson, 2010). A focus in the study is on issues of equity in relation to the teaching and learning of mathematics for Pāsifika students. The continuing low mathematical achievement of Pāsifika students in mainstream schools in Aotearoa New Zealand is a challenge for educators and policy makers alike. Educational researchers in the 21st century have shown that a culturally responsive pedagogy could be a possible solution.

The primary research objectives of this study are identified and an overview of the thesis is presented.

1.2 BACKGROUND TO THE STUDY

1.2.1 PĀSIFIKA STUDENTS

This research project focuses on a group of Pāsifika students and their mathematics learning. The term Pāsifika refers to a heterogeneous group of people who originated from the island nations in the South Pacific. Pāsifika students as a group achieve significantly lower results in mathematics than their European New Zealand counterparts. Although this group obtained a 2.4% increase in achievement from 2012, they are still over-represented in terms of low mathematics achievement (Ministry of Education, 2014). According to the 2013 Mathematics results of National Standards, 60.8 % of Pāsifika students in years one to eight achieved at or above national standards which was still about 14% below the national average and 20% below the Pakeha/European cohort. The Pasifika Education Plan 2013-2017 (MOE, 2013), has called for a focus on lifting the school performance of Pāsifika students to 85% achieving National Standards and NCEA level 2 by 2017. This plan advocates that teachers draw

upon Pāsifika cultural values, languages, and identities to make links to curriculum areas and provide Pāsifika students with equal access to quality education.

1.2.2 CULTURALLY RESPONSIVE TEACHING

Culturally responsive teaching is deliberate teaching to attend to the mismatch between a student's home culture and the school culture (Ladson-Billings, 1992). It means that teachers proactively move beyond superficial, culturally appropriate, tokenistic efforts to meet the needs of their students to using evidence and research to inform their practice. Culturally responsive teaching is validating, comprehensive, multidimensional, and empowering (Gay, 2010). It is validating because it affirms and strengthens a student's identity. It is comprehensive because it addresses the needs of the whole child. It is multidimensional because it encompasses the curriculum, learning environment, student-teacher relationships, instructional strategies, and formal assessments. It is empowering because it enables students to be successful learners and productive citizens (Gay, 2010).

The ethic of caring (Noddings, 2008), is central to culturally responsive practices. It is related not only to Pāsifika students' academic achievement, but also to students' holistic growth as successful participants in societies that value their own cultures. When teachers truly care about their students, they have high esteem for them and view them as competent. Students, in turn, rise to the occasion by showing high levels of social, cultural, and intellectual behaviour. Teachers provide instructional support in order for students to move from what they know to what they need to know. They model the process, extend students' thinking and abilities and possess in-depth knowledge of both the students and the subject matter (Gay, 2010). In this study it is of particular significance as to what teacher actions are responsive to engage Pāsifika students in mathematical discourse.

Research shows that students of diverse backgrounds often have different ways of knowing, talking, and interacting and their background is not often acknowledged or supported by teachers from mainstream cultures (Delpit,

1988). In such cases, poor performance can be linked to inappropriate instructional practices that are insensitive to the social and cultural needs of the Pāsifika students (Tuafuti, 2010). Walshaw and Anthony (2008) contend that effective teachers use a range of organisational and instructional practices to enhance students' mathematical thinking and ways of communicating. Allowing students opportunities to construct their own solution strategies to solve mathematics problems within their culture is motivating and encourages students to value multiple perspectives (Johnson, 2010).

Culturally responsive teaching fits in with reformed mathematics education where the teaching and learning of mathematics emphasises problem solving and effective communication skills (e.g., Bell & Pape, 2012; Chapin, O'Connor, & Anderson, 2013; Goos, Galbraith, & Renshaw, 2004). An essential notion of the inquiry classroom is one where teachers and students are actively working together to enhance mathematical understanding through effective mathematical practices. Drawing on Pāsifika values of respect, family, and collectivism enables student reasoning by way of explanation, justification, and validation in culturally appropriate ways (Bills & Hunter, 2015).

A number of researchers (e.g., Hunter & Anthony, 2011; Spiller, 2012) have called for further research focused on the development of culturally responsive teaching to foster Pāsifika students' participation and engagement in mathematical discourse. If learning opportunities are to be created for all, it is necessary for teachers to find out about students' cultural backgrounds, and what they know and think about while learning mathematics (Bills & Hunter, 2015). This is particularly important in a New Zealand context where Pasifika and Maori students' underachievement continues to be noted.

Furthermore, while international research has reported on culturally responsive teaching for students of various cultural backgrounds (Gay, 2010); research on Pāsifika and Maori students in primary school mathematics settings in New Zealand is relatively limited. It is against this background and for these reasons that this study was conducted on how teachers can support Pāsifika students' mathematical discourse in culturally responsive ways.

1.3 RESEARCH OBJECTIVES

The main objective of this study is to explore how a teacher draws on Pāsifika cultural practices and values to engage students in mathematical discourse. The study also seeks to examine the ways in which teachers support Pāsifika students to construct mathematical understanding. A related objective is to explore the classroom environment connecting the effects of specific classroom practices on the participants as they engage in mathematical reasoning.

In particular, the following research question will be addressed:

How can teachers support Pāsifika students to engage in mathematical discourse in culturally responsive ways?

1.4 OVERVIEW

Chapter 2 reviews the literature from both a New Zealand and an international perspective, providing the background in which to situate the current study. The context and framework for the current study are provided through analysing and connecting relevant literature related to culturally responsive teaching that supports mathematical discourse in an inquiry classroom, collaborative interaction and communication, social and socio-mathematical norms, and the use of mathematical language.

In Chapter 3, the methodology for the study is discussed. The research setting and sample, data collection, and data analysis are described and a timeline for the case study is presented.

Chapter 4 and 5 present the findings of the study and the discussion of these findings. The culturally responsive teacher actions to support Pāsifika students in mathematical discourse are outlined. The teacher's actions in drawing on Pāsifika values and cultural contexts to develop a safe learning environment and group collaboration to support mathematical discourse are illustrated.

Finally, in chapter 6, the study's conclusion is drawn and suggestions for further areas of research are described.

CHAPTER TWO – LITERATURE REVIEW

2.1 INTRODUCTION

The previous chapter outlined the background context of the current study. This chapter reviews research literature both from a New Zealand and international context and provides the theoretical framework on which this study is based. In the western world, mathematics education reform has advocated a shift towards increased use of communication and problem solving activities within the mathematics lesson (Goos, 2004). Mathematical practices such as constructing arguments and critiquing the reasoning of others are central to learning and doing mathematics. For example, in the United States of America, (Common Core State Standards, 2012) advocate that teachers need to guide students to:

justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose...also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which flawed, and – if there is a flaw in an argument – explain what it is. (p. 6-7)

Similarly, within the New Zealand context, New Zealand Mathematics Curriculum (Ministry of Education, 2009), also emphasises problem solving, reasoning, and communicating mathematical ideas. However, there is limited guidance on how to successfully achieve this within New Zealand primary schools, particularly in culturally diverse classrooms. This review of the literature investigates teaching practices to support Pāsifika students to engage in mathematical discourse in culturally responsive ways.

Section 2.2 examines literature on socio-cultural theory, in particular the place of the zone of proximal development in relation to constructing mathematical knowledge. Section 2.3 examines the critical role of the teacher in establishing the social and socio-mathematical norms which shape effective participation structures in the mathematics classroom. Section 2.4 examines the nature of

mathematical discourse and collective interaction in developing conceptual knowledge. The role of language and effective practices in using explicit mathematical language are discussed. Relevant literature is reviewed in Section 2.5 on culturally responsive pedagogical practices and associated outcomes for Pāsifika learners.

2.2 DISCOURSE IN THE MATHEMATICS CLASSROOM

Traditionally, mathematics learning at school drew on a model of “whole class, teacher-dominated didactic instruction and individual seatwork” (Forman, 1996, p. 115) which valued memorization of number facts and students obtaining accurate answers through the flawless use of systematic procedures. Given that the teacher was the dominant voice in the transmission of knowledge, discourse interactions between the teacher and students typically an IRE (Initial-Response-Evaluate) model (Goos, Galbraith, & Renshaw, 2004). However, in recent times, mathematics education reform has promoted a shift in classroom practices to focus on communication, collaborative interaction, and understanding of deeper mathematical ideas (Anthony & Hunter, 2005; Kazemi & Hintz, 2014; Wells, 1999). The discourse is focused on generating meaning (dialogic discourse) where the teacher and students are in a more balanced partnership in the dialogue.

In the words of Gee and Clinton (2000) discourses are described as:
ways of talking, listening, reading and writing - that is using social languages - together with ways of acting, interacting, believing, valuing and using tools and objects, in particular settings at specific times, so as to display and recognise particular socially situated identities. (p. 118)

Discourse in a mathematics classroom fosters a learning community as students and teachers interact with each other and engage in meaningful dialogue or talk to make sense of mathematical concepts and conjectures which are negotiated and developed (Cobb et al., 2011; McCrone, 2005).

Communication is central to learning mathematics and language is an integral part of discourse to communicate mathematical ideas (Moschkovich, 2012). Using mathematical language is important to develop deeper understanding of mathematical ideas. It involves both social language and specific mathematical terms (Johnson, 2010). As reported in Khisty and Chval's study (2002) of two highly competent fifth grade teachers, both teachers created a positive learning environment and recognised that interaction among students and between students and teachers was important. However, one teacher neglected the consistent use of rich mathematical language and subsequently her students did not develop their fluency in the discourse of mathematics. In contrast, the other teacher in the study assisted her fifth grade Latino students to develop competent control of mathematical discourse. These students made significant gains in mathematics in explicitly using mathematical talk. For example, a student's concise explanation of their group's solution for the perimeter of a three-quarter circle was as follows: *we multiply by pi to get the circumference of the circle, then we divide it by four to get the quarter circle. Then we multiply by three to get the curvy part of the three-quarter circle* (p.163). The researchers concluded that the teacher's consistent and explicit use of mathematical talk ensured that the student had access to the words necessary for such an explanation.

Other studies (e.g., Johnson, 2010; Moschkovich; 2012; Selling, 2014) also support the notion that mathematical discourse requires explicit teaching and guidance. Moschkovich (2012) argues that teachers need to provide multiple opportunities for students to use mathematical language so that they can internalise the language and express mathematical ideas fluently. Engaging students in discourse fosters the development of mathematical language which enhances the conceptual meaning and understanding of mathematical ideas. Johnson (2010) supports this premise and contends that students need to be exposed to many contexts to give purpose for the language so that they can develop a meaningful grasp when applying a concept to real-life problems.

A learning theory which supports discourse as a key way to learning mathematics is the socio-cultural perspective that draws on Vygotskian ideas of

cognitive development connecting the person with the setting, social, and cultural factors (Goos, 2004; Sfard & Cobb, 2006).

2.2.2 SOCIO-CULTURAL THEORY

Vygotskian cognitive learning theory places emphasis on the social aspect of learning. Learning is seen as a social activity; the social origins of thinking and logical reasoning are created by social processes, inclusive of language and communication. Language has two functions:

as a communicative or cultural tool we use for sharing and jointly developing the knowledge – “the culture” – which enables organised human social life to exist and continue... and as a psychological tool for organising our individual thoughts, for reasoning, planning and reviewing our actions.(Mercer, 2000, p. 10)

Socio-cultural learning perspectives emphasise the importance of context. Learning is seen as contextualised, which is to view learning-in-activity within social, cultural, and institutional contexts. These social organisational processes are not considered merely as factors which may support or hinder learning, they are integral features of the learning itself (Foreman, 1996). Foreman argued that the three crucial constructs: activity setting, peripheral participation, and instructional conversation, play a central role in socio-cultural theory.

The activity setting or learning environment can be understood as the relationship between thinking and learning, as well as the space and cultural tools within which thinking and learning occurs. Instead of viewing learning purely as residing within the individual, participation in the activities of a community is vital to learning (Lave & Wenger, 1991). Within a community, all participants are legitimate members with some members more knowledgeable than others (such as the teacher or older students), while other members (often the new students) are more peripheral. Mathematics classrooms as communities of practice have a united purpose through a common goal and collective social activity. Taking the contemporary participationist approach (Sfard & Cobb, 2006), learning mathematics is conceptualised as joint

participation in shared cultural activities that occurs in or outside of classrooms. Within this theoretical view, learning takes place when there are changes in the patterns of participation in discourse.

Framing learning as a discursive practice, Goos and colleagues (2004) contend that knowledge is constructed through reasoning and argumentation. As part of the community of learners, the students and the teachers use dialogue as a means of communicating what they know and as a way to construct understanding of new concepts or ideas. The processes of learning and teaching are interactive both involving implicit and explicit negotiation of mathematical meaning. This instructional conversation between teachers and students is not static but it is in a state of construction and reconstruction (Mercer, 2000; Sfard & Cobb, 2006). Mutual accountability regulates the social participation between all participants whereby teachers and students work out who is responsible for what and to whom, what is important, what can be ignored and how to act or speak appropriately (Goos, 2014).

Socio-cultural theorists believe that collaboration and dialogue are crucial for the transformation of external communication to internal thought. It is through the act of joint participation in activities that teacher and students are afforded opportunities to learn new knowledge and skills (Bell & Pape, 2012; Mercer & Littleton, 2007). However, it is important to note that participation in a community alone does not ensure significant mathematical learning takes place (Kazemi & Hintz, 2014; Lampert, 1998). Learning mathematics with understanding is a process that requires time for students to develop their wider mathematical practices within the support of a community (Goos, 2004; Yackel, 1995). Therefore, it is necessary to organise the learning environment so that it is socially and culturally safe for diverse learners to make conjectures and to practise explaining or justifying their mathematical ideas (Johnson, 2010; Spiller, 2012).

2.2.3 ZONE OF PROXIMAL DEVELOPMENT

In Vygotsky's original work of social learning, the zone of proximal development (ZPD) was described as being the difference between what a child is able to achieve individually and independently, and what a child can potentially do in

collaboration with the significant others (Mercer, 2000). The ZPD is traditionally linked to the notion of scaffolding used by Bruner (1990, 1996). In this arrangement, scaffolding supports the learner to achieve the learning goal. The learner is not a passive member; rather, active participation is required in the negotiation of meaning.

In contrast to the traditional ZPD metaphor of an expert guiding an apprentice to learn within the zone, interthinking, a contemporary view of the ZPD perspectives offers a more empowering model of learning (Mercer, 2000). Mercer referred to student inquiry of each other's reasoning in the ZPD as "interthinking" (p. 141). In this frame, learning is viewed as happening in a mutually unrestricted space which is known as the "intermental" (social) development zone where the shared knowledge and goals of all community members are created. The learning in this zone alters constantly as the students and teacher are required to consult and discuss their way through the activity together. It is a process in which participants in the discussion can see and think together and come to share a point of view or taken-as-shared-knowledge .

The idea of participation within a mutual communicative space broadens the traditional view of the ZPD beyond scaffolding and guided participation to one where learning takes place through collective participation and active engagement in meaning making (Goos, 2004; Mercer, 2002). Through joint activity, the participants are able to negotiate each other's meaning and endeavour to understand the diverse viewpoints of the community (Hunter, 2010). This "intermental" zone allows participants to work through partial mathematical knowledge, misconceptions, confusion, and uncertainty (Goos et al., 2004; Yackel, 2002). This requires the active engagement of all participants so that everyone shares responsibility in the collective inquiry of mathematical understanding. More recently, this "intermental" zone has been linked with the culturally responsive description of a "third space" of intellectual engagement by Lipka, Yanez, Andrew-Ihrke, and Adam (2009) where students' views intermingle and cross cultural borders (Gay, 2010).

Another contemporary perspective of ZPD is the symmetrical model of reciprocal learning that advocated that teachers, and not just students, may be learning through classroom interactions. As Roth and Radford (2010) explain:

the zone of proximal development is an interactional achievement that allows all participants to become teachers and learners. (p. 303)

Roth and Radford described the reciprocal learning sequence of a geometry lesson. Twenty-two year two students were asked to classify three-dimensional shapes according to their geometrical properties (for example, cubes, spheres, rectangular prisms). The conversation illustrates how the teacher guided the students but in turn they guided her in relation to the assistance that they required. Through the exchange of questioning and the language use in communicating mathematical ideas, a clear model of reciprocal learning was shown as teacher and the students were learning from each other.

2.3 DISCOURSE PRACTICES WITHIN INQUIRY CLASSROOMS

The term "Inquiry" is synonymous to reformed mathematics learning. Setting up inquiry classrooms is important in facilitating mathematical learning. According to Cobb and colleagues (2011) students need opportunities to jointly participate in mathematical practices through classroom interactions. They are expected to be actively engaged in thinking, doing, talking, and reasoning mathematically. Within such classrooms, the mathematical practices involve student questioning and participation in meaningful mathematical activity, collaborative work to construct understanding, and the creation of an environment where errors can be capitalised as learning opportunities (McCrone, 2005; White, 2003). The classroom discourse may include whole-class discussions, small groups collectively solving problems, discussion of solution strategies, sharing of conjectures, explanation or justification, and student reflection on their own work or the work of their group members (Lamberg, 2013; Manoucheri & St John, 2006; Kazemi & Hintz, 2014).

Within inquiry classrooms, learning mathematics is a collective endeavour (Goos, 2004; McCrone, 2005). All participants, both students and teachers,

have responsibility to develop a social community of learners. All students are expected to explain and justify their mathematical ideas, listen and learn from others, and build on each other's thinking.

2.3.1 SOCIAL AND SOCIO-MATHEMATICAL NORMS

Collective participation in inquiry classrooms is shaped by social norms (Goos, 2014; Yackel & Cobb, 1996). Social norms are the common ways in which students take part in any classroom activities and in any curriculum subject. These include such activities as questioning, listening, turn taking, explaining, justifying, discussing different ideas, supporting each other within group activities, and making sense of others' explanations (Goos, 2014). These social norms are also linked to culturally responsive teaching because it is imperative to create "a climate and ethos of valuing cooperation and community in the classroom" (Gay, 2010, p. 197) to promote equitable learning opportunities for diverse learners.

Moving beyond social norms, socio-mathematical norms are related to explicit mathematical activities. They include analysing and talking about mathematical concepts, reasoning with a diverse range of tools, offering different strategies, and presenting mathematical arguments to reach a consensus. Additionally, they require the participants to judge what counts as an acceptable mathematical explanation or mathematically efficient solution (Yackel & Cobb, 1996). Students and teachers co-construct the social and socio-mathematical norms of the classroom to ensure equal participation of all students. Through participation in classroom communities, students learn classroom expectations and obligations on how to work on a mathematical activity. As students engage or participate in the negotiation of socio-mathematical norms, they develop mathematical beliefs and values. These help to increase students' intellectual autonomy and enhance positive mathematical disposition. For example, in a study by Cobb et al. (2011), two first grade students used a foot-strip to measure the height of the cabinet. At first both students had different interpretations of what was to be measured, it only became taken-as-shared understanding when both students collectively agreed on the structured space

as a property of the object being measured. With the help of an adult, the students could explain the measurement of the height of the cabinet using a foot-strip.

The development of socio-mathematical norms is essential to maintain the productive functioning of a learning community and to guide the quality of discourse within a classroom (Chapin, O'Connor, & Anderson, 2013). As Wood (2002) explained, the socio-mathematical norms regulate productive mathematical discussion or argumentation in the classroom. Makar, Bakker, and Ben-Zvi (2015) agree with this premise and maintain that both teachers and students are required to be explicit about discourse norms. In particular, students are expected to share not only their solution but also their thinking process in order to convince others of the validity of their solution.

Furthermore, Kazemi and Stipek (2001) maintain that there are key socio-mathematical norms which are linked to a high press for conceptual thinking. These include:

an explanation consists of a mathematical argument, not simply a procedural description or summary, mathematical thinking involves understanding relations among multiple strategies, errors provide opportunities to reconceptualise a problem, explore contradictions in solutions, or pursue alternative strategies, and collaborative work involves individual accountability and reaching consensus through mathematical argumentation. (p. 64)

In their study, Kazemi and Stipek (2001) reported on four teachers in grade four and five classrooms, who all taught the same lesson on the addition of fractions. The researchers analysed conversations that created a higher or lower press for conceptual thinking. They found that in a low-press interaction, the class applauded the correct solution without analysis and the teacher glossed over inadequate or inaccurate solutions. However, in high-press exchanges, students explicitly linked their problem-solving strategies to mathematical reasons.

2.3.2 THE ROLE OF THE TEACHER IN THE INQUIRY CLASSROOM

Teachers play a significant role in the development of an inquiry classroom. Goos and colleagues (2004) investigated the patterns of classroom social interactions that improved Year 11 and 12 students' mathematical understanding. They demonstrated how the teacher facilitated a mathematical classroom inquiry community of practice. The teacher modelled the desirable mathematical thinking, discourse, and made explicit reference to mathematical language and symbols. Students were required to reflect and monitor their own thinking and reasoning. The teacher advanced student thinking by scaffolding inquiry practices and asking questions such as "how is this?" and "what is the reason for this?". Furthermore, the teacher expected the students to take ownership in validating their own solutions; each student needed to develop clear explanations and justification of solutions in order to make personal sense of concepts.

Across a range of research studies focused on developing inquiry with mathematics classrooms (e.g., Hunter, 2007; Goos, 2004; Makar et al., 2015; White, 2003), researchers note that the teacher's contribution to the discussion was to enrich the mathematical dialogue rather than to reduce the cognitive load of the students' task. These studies show that discourse promoting conceptual thinking can be achieved through specific teacher actions. The teacher takes a key role in promoting students' engagement in mathematical discourse (Makar et al., 2015; Yackel, 1995). In McCrone's study (2005) of a year five classroom, the teacher specifically facilitated the development of specific behaviours in the classroom. In the first observation students did not actively listen to each other nor were they able to articulate their reasoning. As a facilitator and participant of the learning community, the teacher steered shifts in the discourse to ensure that students began to use mathematical reasoning and were conceptually focused on the collective task. As the term progressed, students began to listen, interpret, and respond to each other's contributions.

Supporting students' active engagement is an important part of discourse rich classrooms. Effective teachers organise activities to encourage and support

students' contributions to mathematical discourse, particularly for shy or less confident students. In Rittenhouse's study (1998) of a year five classroom, the teacher responded to the needs of the students and made the conversation more comprehensible by providing the explicit words for students to participate in the discussion. When students reported back on behalf of a group in the study, they were contributing the group shared ideas rather than an individual idea. This exemplifies the important role of the teacher in guiding students on the peripheral to draw them into full participation in mathematical discourse (Rittenhouse, 1998).

Teachers contribute important resources to a discussion by introducing mathematical language, signalling a new idea, connecting with previous learning and summarising key mathematical ideas (Khisty & Chval, 2002; McChesney, 2009). An example from the study by Khisty and Chval (2002) illustrates this. In this case, the teacher consistently made her mathematical talk explicit so that students could access the language they needed to participate in the discussion. In the classroom, students were expected to use correct mathematical terms and complete their mathematical explanation in full sentences. Connections were made between important ideas, for example, the teacher built both on the word *opposite* which the student knew to connect to a new word *inverse* and relational understanding that multiplication is the inverse of division. In this case, the explicit use of mathematical language enhanced the conceptual understanding of students.

Another key role teachers take is using questions and prompts to develop students' use of mathematical explanations. Franke and colleagues (2009) showed how teachers effectively used different types of questions and prompts to support students making complete and correct explanations when developing algebraic reasoning in elementary classrooms. Previous studies (e.g., Khisty & Chval, 2002; Moschkovich, 1999) have shown specific evidence that teacher-led questioning supported the development of mathematical language to engage in discourse which led to better conceptual understanding.

To foster student active engagement in discourse, teachers can also position students to take a specific stance to justify their thinking in mathematical discourse. In a New Zealand study led by Hunter (Alton-Lee, Hunter, Sinnema & Pulegatoa-Diggins, 2010), she reported that the teacher regularly halted students' explanations and required students to take a stance:

At some point, you are going to have an opinion about it. You are going to agree with it or disagree with it...Make sense of it. If you don't agree, say so but say why. If there is anything you don't agree with, or you would like them to explain further, or you would like to question, say so. But don't forget that you have to have reasons. Remember it is up to you to understand. (p. 12)

Through these actions, students become increasingly aware of the importance of validating their opinions with mathematical reasoning, not only to ensure they understand the mathematics themselves but also because they are accountable to the whole learning community in constructing new knowledge.

Within the inquiry classroom, teachers use tasks to specifically facilitate students' mathematical learning (Sfard & Cobb, 2006). Anthony and Walshaw (2007) in a synthesis of research studies that inform practice, commented that "in the mathematics classroom, it is through tasks, more than in any other way, that opportunities to learn are made available to the students" (p. 96). When designing tasks teachers need to consider the mathematical goals, as well as maintaining the level of cognitive demand. Contexts also need to be experientially real to foster student engagement in class discussion (Jackson, Shanhan, Gibbons, & Cobb, 2012). Jackson et al., (2012) argue that students engage in complex mathematical tasks when teachers discuss the contextual features and any unfamiliar language (specific terms or phrases) of the problem. These researchers explain that it is equally important for all participants to develop a common language to describe the key features of the task during discussion.

Challenging tasks foster student engagement in productive discourse with the careful support given by the teacher (Cobb et al., 2011, Rittenhouse, 1998). In enacting challenging tasks, the teacher takes a more active role than “not telling”. The teacher is required to actively listen to the students’ ideas in order to relate to the contributions made by various students about the tasks (Brodie, 2007). In addition, sometimes teachers need to provide additional information, missing links or an overall picture for the discussion to shape the mathematical ideas that are worth talking about (Brodie, 2007). Also, the teacher may need to provide additional support such as enabling or extending prompts to assist students to participate in the discussion (Sullivan, Mousley, & Jorgensen, 2009). It is the constant interactive support from the teacher or other members of the learning community that fosters students’ willingness to persevere in finding solutions for the tasks which in turn enhances conceptual understanding.

The discussion above highlights the key role of teachers in influencing the students’ perception about their roles and their expectation of their peers in contributing towards productive mathematical discourse (Manoucheri & St John, 2006). We see from the research studies (Hunter, 2007; Khisty & Chval, 2002; Rittenhouse, 1998) that teachers have a complex role in an inquiry classroom as a task designer, participant, commentator, monitor, and facilitator, but primarily, their role is to promote the development of conceptual knowledge in students and to facilitate shared knowledge in the classroom community through mathematical discourse (Cobb et al., 2011).

2.4 ENGAGING STUDENTS IN MATHEMATICAL DISCOURSE

Mathematical discourse requires mutual collaboration between students and students with the teacher. Effective collaborative interaction requires the students to be active listeners and critical participants. This socialisation process is not an easy task and it takes time to achieve the desired mathematical discourse (Chapin et al., 2013). Franke, Turrou, Webb, Ing, Wong, Shin, and Fernandez (2015) analysed various support moves (e.g. probing, scaffolding, positioning) that teachers used to engage students with

each other's idea, they argued that it was the responsive-in-the-moment support move that allowed students learned how to listen actively to each other and build ideas together in mathematically detailed way.

Some researchers (e.g., McCrone, 2005; Wegerif & Dawes, 2004; White, 2003) argue that an effective way to engage students in mathematical discourse is through the use of small groups. Small group interaction can lead to powerful learning. Wegerif and Dawes (2004) describe how:

Children working in groups can offer one another chances to explore their conceptions, to employ their new vocabulary, and an audience for explanation, planning, suggestion and decision-making. In this way children learn to speak the language of maths. Challenges and explanations in groups, guided by teachers, can lead children to learn more expert ways of talking. (p. 102)

Small group discussion offers many opportunities for students to engage in collaborative dialogue to support the development of mathematical thinking and the resolution of different points of view. The interaction between students helps them to develop new knowledge that makes sense to everyone in the group.

Interactions with peers can empower learning. Goos (2004) explained the way in which one student viewed his interactions with peers in his senior mathematics class as an enriching learning experience:

Adam helps me ... see things in different ways. Because, like, if you have two people who think differently and you both work on the same problem you both see different areas of it, and so it helps a lot more. More than having twice the brain, it's like having *ten* times the brain, having two people working on a problem (p. 278).

However, it is important that teachers provide a supportive group structure - a safe space for asking questions, clarifying ideas testing conjectures, giving and taking critical feedback, and building upon others' strategies and solutions. For example, White (2003) found that English language learners with limited English were more comfortable to share their thinking with a friend rather than with the

whole class. Students clarified their thinking about the context of the problem and put forward a conjecture through peer discussion.

"A lot of the time they won't share something with the whole group. But they will share it with somebody sitting next to them, or they can sometimes get ideas from other kids who are sitting next to them." (p. 42)

Students working collaboratively on solving challenging tasks show a greater level of cognitive engagement than those working independently (Walshaw & Anthony, 2008).

2.4.1 USING EXPLICIT MATHEMATICAL LANGUAGE IN DISCOURSE

Research studies show that mathematical language is central to learning mathematics (Anthony & Walshaw, 2009; Brevik, Fosse, & Rødnes, 2014; Pimm, 1987; Schleppegrell, 2010). When students display fluency and accuracy in using mathematical language in discourse it furthers the development of mathematical reasoning. Developed through social interaction, discourse and language can be seen as a means for organising thinking for logical reasoning (Bruner, 1986; Mercer & Littleton, 2007).

A range of pedagogical practices have been suggested to help students use mathematical language within classroom discourse. In the New Zealand context, Latu (2005) demonstrated that those Pāsifika students that were able to code switch between a first language and the language of mathematics (in English), performed better than those who had only restricted forms of English as their first language. The practice of “translanguaging” — where students receive task information in one language but discuss and record their thinking in another language of choice— has been found to be effective in supporting engagement in discourse in the studies by Garcia & Wei (2014).

Other studies (e.g., Khisty & Chval, 2002; Moschkovich, 1999; Selling, 2014) have shown that English language learners are able to gain fluency and accuracy in mathematical discourse when teachers focus explicitly on the rich

use of mathematical language and specific terms. For example, Khisty and Chval (2002) documented how a teacher supported her 5th grade Latino students within collaborative problem solving activities. It was found to be important to give the students sufficient time to understand the language in the problem and provide multiple opportunities to practise explaining and justifying their mathematical reasoning using the correct mathematical language. The teacher frequently used mathematical words in her talk and capitalised on students' cultural knowledge to make links between mathematical language, students' understanding and their home language. In this study, the teacher capitalised on the students' knowledge of Spanish to have them construct a meaning for quadrilateral (by connecting it to the Spanish word *cuado*). The teacher used her talk not only to extend students' understanding but also to connect it to the meaning of a specialised mathematical term which led to the big mathematical ideas in the problem.

Moschkovich (1999) outlined how a third grade classroom of English second language learners shifted from an informal use of terms to precise mathematical language. The teacher "did not focus primarily on vocabulary development but instead on mathematical content and arguments as he interpreted, clarified and rephrased what students were saying" (p. 18). The teacher listened carefully to what the students were saying, probing and revoicing what they said to maintain focus on the mathematical content of their contributions. As a result, the students gradually mastered both the use of the mathematical language and knowledge of how to participate in mathematical discourse.

2.5 CULTURALLY RESPONSIVE MATHEMATICS TEACHING

Many studies have written about culturally responsive teaching approaches which resulted in successful learning outcomes for diverse students of different ethnicities (e.g., Au, 1993; Averill, Te Maro, Taiwhati & Anderson, 2009; Civil, 2014; Escalante & Dirmann, 1990; Gay, 2010; Johnson, 2010; MacFarlane, 2004). Culturally responsive teaching is a pedagogy that "empowers students intellectually, socially, emotionally and politically by using cultural references to impact knowledge, skills and attitudes" (Ladson-Billings, 1994, p. 17).

Culturally relevant teaching incorporates students' culture into the curriculum to draw on history of students' lives as well as unique ways of communicating, behaving and knowing while preparing students to effect change in society, not merely fit into it. (Ladson-Billings, 1994, p. 17)

One way of developing culturally responsive teaching is for educators to focus on the strengths, that is what the students know instead of what they do not know. White (2003) analysed two third-grade teachers' classroom discourse practices with African American and Hispanic students. In contrast to common practices where teachers often engaged students in repetitive and unchallenging tasks, these two teachers focused on developing students' mathematical competence and creative thinking. They encouraged students to solve problems using their cultural knowledge and resources. They facilitated mathematical thinking by discussing students' ideas and encouraging them to analyse answers to the questions being posed by others. They valued students' ideas, allowed students to share their thoughts without judgement, and encouraged students to take risks to increase the variety of responses. Both teachers focused more on students' thinking and their different solution strategies and less on the correct answer. By asking students to explain their answers, they not only learned how students thought about the problems but also provided the class with multiple ways to think about and solve problems. This study highlights that engaging students in mathematical discourse both maintains a focus on sense making and reasoning while also enabling teachers to reflect on students' understanding and to stimulate mathematical thinking.

Research studies on the use of successful culturally responsive practices offer invaluable insights into how teachers can capitalise on students' culture to facilitate learning. A New Zealand study by Averill and colleagues (2009) looked at a bicultural framework of integrating English and Maori for culturally responsive teaching. The framework incorporated Maori concepts (such as *harakia* or prayer, *kapa haka* – performance, *waiata* – song and *marae* or meeting house) with teaching strategies (such as reciprocal learning – *ako*) (Averill et al., 2009). Similarly, Bills & Hunter (2015) and Johnson (2010) highlight the necessity of teachers incorporating students' culture into classroom

practices by designing task problems that reflect students' culture, using words in their home language, and building on cultural norms.

English language learners, no matter how accomplished their English speaking becomes, still have their native language as a resource (Johnson, 2010). Students may think or reason mathematically to themselves in their native language or sometimes in English or in both languages. Schleppegrel (2010) advocated that teachers should utilise cultural tools of students (such as language, cultural nuances, logic, rhythm, gestures, drawing, materials) as invaluable learning resources in the mathematics classroom because they offer a different perspective in constructing mathematics knowledge. Using these cultural tools from the students' world fosters greater student engagement in mathematical discourse. Moschkovich, (2010) states that teachers should make links with what students bring from home or communities to build on new knowledge and skills in the mathematics classrooms. Civil (2014) extends this notion and argues the need to broaden mathematical communication beyond the normal oral or written exchanges and in English language only. She stresses that the richness of students' thinking in mathematics in their home language, their knowledge and experience should count towards mathematical development.

Central to culturally responsive pedagogy is the caring perspective described by Noddings (2008). The teacher who genuinely cares for the students' learning and organises social and cultural conditions to establish a climate of mutual care and trust. According to Gay (2010) culturally responsive caring goes beyond feelings of empathy and kindness; the focus is turning the students' personal interests and strengths or their cultural ways of doing things into opportunities for academic success. As discussed earlier, dialogue is a powerful learning tool and it is also a culturally effective way to learn mathematics (Gay, 2010). All participants learn from one another through dialogue, not trivial small talk but in the search for meaning and deeper understanding of the tasks. Noddings (2008) argues dialogue is important to learning and it shows how students care for each other's learning. As they talk about their ideas the language they use will be expanded and polished. Progressively, they can develop a logical reasoning through individual contributions.

Teachers who truly care about the development of their students' mathematical competency show interest in how students construct or express their ideas, no matter how unexpected or unconventional they seem. It is by modelling the practice of evaluating of each other's ideas through dialogue that teachers encourage their students to make logical judgements about the ideas voiced by other class members (Anthony & Walshaw, 2009). Classroom routines should be in place so that caring can be encouraged and monitored. Noddings (2008) contends that organising for learning in groups provides opportunities to strengthen the ethos of care. However, for group work to be successful, teachers need to continually remind students that "they are engaged in this work to help one another – not simply to produce a better product or surpass another group" (Noddings, 2008, p. 171).

In a socially and culturally safe classroom, everyone is encouraged to show their mutual understanding of care through respectful dialogue. A key component of respectful dialogue is the use of inclusive language such as "we want to know", "what happens when we...".

Noddings advocates that teachers need to be socially and culturally aware of the unpleasant behaviour that may happen. For example, a classroom member can potentially pick on the more vulnerable students, changing the learning atmosphere from caring to competing. Hence, Noddings (2008) believes that it is necessary for teachers to have a strong grasp of interpersonal reasoning and to maintain caring relations during dialogue when a student is feeling distressed or uncomfortable with the direction the dialogue has taken. Teachers may need to interrupt the flow of discussion to assure the student that "he or she is thinking well" and assure students that it is acceptable to experience indecisions or frustration when working through complex tasks.

It is important to note the conflict of beliefs and emotions that may emerge as Pāsifika learners socialise into the community of mathematical inquiry where practices such as questioning, disagreeing, and challenging have not been common experiences for the students in previous classrooms. Spiller (2012) explains the Pāsifika value of humility may influence some students to hold back from expressing their views. They may refrain from contradicting what has

been spoken because they did not want to look clever in front of their peers. Teachers therefore need to be aware of these values so they can work with students to address these issues sensitively.

Pāsifika learners encompass a diverse group; however, Anae, Coxon, Mara, Wendt-Samu, and Finau (2001) highlight a common set of cultural values which are important to all Pāsifika people. These Pāsifika values include: respect, reciprocity, communalism, and collective responsibility. In Hunter's (2008) study, the teacher incorporated Pāsifika values into the community of mathematical inquiry. The requirement that students worked collaboratively was framed within an appropriate cultural setting (preparing an *umukai* [village feast] and the collaborative roles all participants held). In a year seven and eight classroom, the teacher guided students' attention toward Pāsifika concepts of reciprocity, collectivism and community as the students developed mathematical explanation, representations, and justification with their groups. He called on their concept of respect and reciprocity as prerequisites to actively listening, questioning, checking the understanding of all the members of the group and supporting each other when reporting back to the class (Hunter & Anthony, 2011). The relationships between teachers and students were socially caring and responsive which was central to their positive outcomes.

Research studies (e.g., MacFarlane, 2004; Johnson, 2010; Tuafuti, 2010) show that when collaborative discourse is practised in culturally diverse classrooms students feel secure and empowered when their language, culture, and power is shared. Tuafuti (2010) contends that the culture of silence has relevance in learning for Pāsifika students. It is a sign of respect to people who are in position of authority such as teachers and elders and it is expected for students to listen attentively and learn from the teacher. It is viewed as disrespectful to argue or question teachers or peers. However, students need to be taught how to disagree and argue mathematically to learn mathematics (Spiller, 2012). Tuafuti (2010) advocates that classroom practices should value culture and empower active participation of students in discourse so that their voices are heard. Similarly, Fletcher and colleagues (2005) argue that maintaining the cultural identity of Pāsifika students is one of the important factors in helping

Pāsifika students to succeed in school. Gay (2010) agrees with this premise and suggests that teachers can use culturally appropriate ways to encourage students to contribute to mathematical discussion such as allowing longer thinking time, make the language accessible for them, story-telling, repeating instructions, or choral reading or any preferred way chosen by the students.

Caring for the students' learning is central to culturally responsive practices. Spiller (2012) claims that learning is more effective when teachers take full responsibility for their Pāsifika students. Pāsifika students prefer a learning environment where they have a space to think, and they are allowed to do work for themselves. The work should be interactive and challenging so that the students can respond to the learning opportunities that are purposeful for them. More importantly teachers should:

...show them respect as a person, speak quietly to them, listen attentively to them when they have something they want to say and respond with respect to their ideas and questions...do not singled them out for help, they will ask for help when they need it and they want to be allowed to ask their friends first. (p. 65)

In other words, it would make a difference to Pāsifika students' achievement in mathematics if they were given dignity and opportunities to participate in their learning.

2.6 SUMMARY

To meet the needs of diverse learners, mathematics education reforms advocate changes to teaching and learning practices that include a focus on personal, social, and cultural factors. Mathematics inquiry classrooms reflect the aims of reform education in that they provide opportunities for students to become active participants of an effective learning community, and construct mutual understanding through collaborative discourse. Within inquiry classrooms, the teacher takes on an important role in guiding the construction of the social and socio-mathematical norms associated with productive mathematical discourse. The literature also highlights the pivotal role the teacher takes in guiding the students' roles as active listeners and participants to ensure productive mathematics discussion and collaborative interaction happens. Many research studies have shown how students' mathematical reasoning is enhanced through participating in discourse with the appropriate use of mathematical language.

Adapting culturally responsive pedagogical practices to enable all students to participate and contribute in mathematics classrooms is a key equity issue. Emphasis is placed on using the cultural capital of Pāsifika learners to improve their participation, engagement, and outcomes in mathematical learning. In the increasingly diverse classroom contexts, mathematics teachers are in fact language teachers of mathematics as well as cultural facilitators. Teachers' actions are central to the orchestration of productive mathematical discourse in a culturally responsive and collaborative learning environment. When students are positioned to be held accountable for completing the mathematical activity, they are empowered to become academically competent in mathematics with the support of the learning community.

CHAPTER THREE – METHODOLOGY

3.1 INTRODUCTION

The previous chapter outlined the theoretical framework for the current study. This chapter provides an overview of the research design. Section 3.2 presents justification for the selection of a qualitative approach for this research project and describes the use of a case study method. Section 3.3 outlines the role of the researcher. Section 3.4 provides details on the setting, the participants, and the research schedule. Section 3.5 discusses the data collection methods used in this study. Section 3.6 explains the process of data analysis. Section 3.7 considers the steps taken to preserve the validity and reliability of the findings of the study. Section 3.8 summarises the methods used to ensure that ethical standards were maintained at all times.

3.2 JUSTIFICATION FOR METHODOLOGY

3.2.1 QUALITATIVE RESEARCH – AN INTERPRETIVE PARADIGM

This study aims to investigate the key research question:

- How does a teacher support Pāsifika students to engage in mathematical discourse in culturally responsive ways?

The study is guided by a qualitative interpretive research paradigm (model of inquiry). This view frames reality as a social construct in which the interpretation of the lived experiences needs to be understood from the views of the observed in context (Burton, Brundrett, & Jones, 2014). Often, there are “multiple realities or interpretations of a single event” rather than a single observable reality (Merriam, 2009, p. 9). Taking Patton’s description (1985, quoted in Merriam, 2009):

Qualitative research is an effort to understand situations in their uniqueness as part of a particular context and the interactions there. This understanding is an end in itself, so that it is not attempting to predict

what may happen in the future necessarily but to understand the nature of that setting – what it means for participants to be in that setting, what their lives are like, what’s going on for them, what their meanings are, what the world looks like in that particular setting – and in the analysis to be able to communicate that faithfully to others who are interested in that setting... The analysis strives for depth of understanding. (p. 6)

This study strives to provide an in-depth understanding of the ways in which a teacher supports Pāsifika students to participate in mathematical discourse. Qualitative research was chosen for this study because it allows a systematic investigation to take place in a social context. It focuses on the processes rather than the product. In terms of the current study, the qualitative research design aims to capture the different aspects of culturally responsive teaching which are drawn on to facilitate classroom discourse. A key emphasis is on making meaning from the perspectives of the teacher and the Pāsifika students in the natural setting—one primary mathematics inquiry classroom.

Qualitative research employs an inductive approach to “find a theory that explains their data” (Goetz & LeCompte, 1984, cited in Merriam, 1998, p. 4). This contrasts with quantitative research which uses a deductive approach to find data to match a theory (Yin, 2012). Qualitative studies are undertaken because “there is a lack of theory or existing theory fails to adequately explain a phenomenon” (Merriam, 2009, p. 7). While there is a body of literature that documents the discourse patterns in mathematics inquiry classrooms (Chapin, O’Connor, & Anderson, 2009; Civil & Planas, 2004; Cobb, Stephan, McClain, & Gravemeijer, 2011; Hunter, 2007; Kazemi & Hintz, 2014), there is a lack of classroom-based research that specifically examines how teachers support Pāsifika students to engage in mathematical discourse in culturally responsive ways.

3.2.2 CASE STUDY

After a critical review of various research methods, a qualitative case study approach was adopted for the research design. Case study research enables a detailed investigation of one site and one group in a naturalistic environment encompassing historical, social, and cultural contexts. According to Yin (2010), case study is a holistic form of research. It is characterised by multiple sources of data being collected to generate rich descriptions in order to support the theoretical assumptions, and to build on knowledge that supplements further research (Burton et al., 2014; Merriam, 1998).

In this study the research builds on concepts, hypotheses or theories rather than testing existing theory. A case study of one classroom is used to describe a teacher's culturally responsive actions to engage Pāsifika students to talk about their mathematical thinking and ideas. This study explores the construction of mathematical discourse within an authentic setting of a classroom. It also investigates the culturally responsive tasks and teacher practices which support Pāsifika students' mathematical learning.

There are many varied forms of case study designs; each with its own purpose, methods, and complexity (Berg & Lune, 2012; Merriam, 1998). The case study research can be solely descriptive in nature or interpretative where data is analysed to develop categories attributed to the task; or descriptive and evaluative which permits explanation and judgement to take place within data analysis (Merriam, 1998).

An interpretive case study is appropriate for this project because the data provides holistic descriptions of the classroom interactions which are used to support theoretical conclusions. Rather than just describing what was observed or what the students' responses were to their teacher's instructional practices, taking the interpretative approach allows the researcher to analyse all the data and develop categories of culturally responsive practices. In this way the study aims to develop an in-depth understanding and expand the range of interpretation of the teacher's actions.

3.3 RESEARCHER'S ROLE

Merriam (2009) contends that the researcher is the *main instrument* in qualitative studies. The role of the researcher in this study was as the sole collector of data and as a participant observer. Initially, the researcher spent three days in the classroom getting to know the teacher's mathematics programme and observing the students' engagement in mathematical discourse. The students understood that the female researcher was a primary school teacher who had been teaching students of similar Pāsifika backgrounds. The relationship between the teacher and researcher was professional. As the primary instrument for gathering and analysing data, the researcher needs to collect, interpret, understand, and produce meaningful information (Berg & Lune, 2012). The researcher's experiences in using an inquiry approach to teach mathematics with Pāsifika students meant that the researcher was familiar with expected classroom practices, learning objectives, and potential pitfalls or outcomes. The researcher shared her interpretation of events with the teacher during each visit and provided space for the teacher to either support or refute the researcher's viewpoint.

3.4 THE RESEARCH SETTING, SAMPLE AND SCHEDULE

This section outlines the setting for the study, information on the participants and the phases of the study.

3.4.1 THE SETTING AND THE SAMPLE

This research was conducted at a suburban full primary school during term one and term two of the 2015 school year. Kelly School (pseudonym) has a decile¹ rating of one. The students attending this school are from low socio-economic

¹ Each state and integrated school is ranked into deciles ranging from 1 to 10. Decile 1 schools draw students from low socio-economic communities. The lower the school's decile, the more state funding it receives.

communities and predominantly of Pāsifika ethnicity. Each teacher at Kelly School has been involved in the professional development to support the development of mathematical inquiry communities in their classrooms for the past two years (see Hunter, 2007).

The research took place in a Year Seven and Eight composite class. The teacher, Mr J, has taught for eight years and was in his third year of working to build mathematical inquiry communities. Following an invitation from the researcher, Mr J agreed to be involved in the research, viewing it as an opportunity to reflect on his own practice and provide insights towards his postgraduate study.

There were 28 students in this class and 15 Pāsifika students agreed (with parental consent) to participate in the research. Mathematics in this classroom consisted of the students working collaboratively in heterogeneous groups to solve mathematical problems. The problems were set to cover Mathematical Curriculum Levels from Level Two to Four of the New Zealand Curriculum Document; equating to Numeracy Level Stages Five to Eight of the Numeracy Professional Development Projects (Ministry of Education, 2009).

3.4.2 THE RESEARCH STUDY SCHEDULE

This study consisted of three phases of data collection over five months (February-June, 2015) and involved 15 lessons. The summary research timeline (see Table 1) provides an outline of the research schedule and further details of the activities and problems used in each three lesson block are provided in Appendix B.

Table 1. Summary timeline of research schedule

Date	Field work details
Phase one- 6 lessons Term 1 Week1 Initial Meeting	Meeting with the school principal and teacher participant regarding research's purpose and outline, discuss consent for school, teacher, and students
Week 2	Researcher is introduced to class by the teacher

	<p>Three days of observations</p> <p>Classroom Task: Filling up the petrol (See Question 1 Appendix two)</p> <p>Two meetings with teacher participant to discuss about lesson plans and students backgrounds. Collate the consent forms from the students/parents/teacher</p>
Week 7	<p>Meeting with the teacher to discuss Term 1 week 2 data</p> <p>Three days of classroom observations</p> <p>Classroom Task: Sunday Feeds (See Question 2 Appendix two)</p>
Phase Two - 9 lessons Term 2 Week 1	<p>Meeting with the teacher to discuss Term 1 week 7 data</p> <p>Three days of classroom observations</p> <p>Classroom Task: Estimating volume and measurement for Ta'ovala (Tongan's traditional mat skirt- See question 3 Appendix two)</p>
Week 4	<p>Meeting with the teacher to discuss Term 2 Week 1 data</p> <p>Three days of classroom observations</p> <p>Classroom Task: finding the area of a Tivaevae (Cook Island's patterned quilt- See question 4 Appendix two)</p>
Week 7	<p>Meeting with the teacher to discuss Term 2 week 4 data</p> <p>Three days of classroom observations</p> <p>Classroom Task: Finding fractions, percentages and decimals using the sharing of pizzas – See question 5 Appendix two)</p> <p>Individual interviews with fifteen students</p> <p>Post-interview with teacher participant</p>

Phase One: Preparation and data collection

An initial meeting between the researcher and the teacher took place before commencing any data collection. Their purpose of the meetings was to discuss the research plan, the objective of the study, the timeframe for data collection, and the consent forms for the teacher, students, and the school. The teacher

introduced the researcher to his class and explained the purpose of the project. Students were invited to participate and consent forms were sent home. In the second visit, the consent forms from the teacher, parents, and students were collated. The researcher spent six lessons in the class with the video recorder positioned facing the teacher and the audio recorder by the teacher at the front of the class so that students could become familiar with the presence of the researcher and the data collecting tools.

Phase Two: Data collection

Data collected during the nine observed lessons included video and audio footage of the students' collaborative interactions during problem-solving activities, written samples of group work, teacher developed lesson objectives, and researcher field notes. Individual interviews with 15 students were conducted at the end of the study. Additional data included reflective discussions between the researcher and the teacher following each lesson. These discussions were audio-recorded and transcribed as part of the lesson's footage. Transcriptions of the lessons and data from interviews were analysed by the researcher to identify a range of actions the teacher utilised. The results were sent to the teacher participant and meetings were held with the teacher prior to the commencement of the next phrase to cross-check the validity of the data.

Every lesson followed the same format. They were 50-60 minutes in length. They began with the teacher launching a contextual mathematical problem to the big group. The students in small groups of three or four worked collaboratively to solve the problem for approximately 15-20 minutes. During this time the teacher monitored student reasoning and interjected in group discussions as necessary. This included him seeking clarification on the written work presented, extending the mathematical discourse, and ensuring social and socio-mathematical norms were being enacted. In the final plenary, the small groups were called together to form one large group. The teacher then carefully sequenced the student discussion of the reasoning they used to solve the problem.

At the conclusion of the lesson observations, the researcher interviewed the teacher (See Appendix A). The questions explored how Mr J used culturally responsive ways to support Pāsifika students' engagement in questioning, agreeing, disagreeing, mathematical explanations, and argumentation. Fifteen students were interviewed (See Appendix A for interview schedule) to explore their perceptions of the teacher's actions and support for their mathematical learning. In a post-research interview the researcher and teacher reflected upon and verified the emerging data.

3.5 DATA COLLECTION

Case study research provide flexibility and multiple sources of evidence (Yin, 2012). Employing multiple methods of collecting data allows rich and unique data to be surfaced (Lichtman, 2013; Merriam, 2009). Multiple sources of data are used because “no single source of information can be trusted to provide a comprehensive perspective” (Patton, 1990, p. 214 quoted in Merriam, 1998). Multiple data can help the researcher uncover meaning, develop understanding, and discover insights relevant to the research problem.

The qualitative data collection for this study included observations, interviews, classroom artefacts, and detailed field notes (commentaries of the lessons observed and reflections on the interviews). Triangulation of data collected through multiple sources of evidence, enabled the establishment of the validity and reliability of the study.

3.5.1 OBSERVATION

Observations, a primary data source in qualitative research (Yin, 2012), were made through video recording, with the aim of capturing the moment-to-moment detail of complex classroom interactions. Audio recordings were made simultaneously to ensure clear audio data. Video-recorded observation has become widely used in research to collect and archive large amounts of both

visual and audio data within the natural contexts of classrooms (Berg & Lune, 2012; Burton et al., 2014). Viewing the footage offers time for reflection on what has been observed (Sherin, Linsenmeiser, & Van Es, 2009).

This study involved a sequence of video-recorded teaching episodes. In each lesson, the primary objective was to record the interaction between the teacher and the students. At the beginning of each lesson, the teacher normally outlined and discussed the targeted mathematical problem with the students. Following this, the camera was positioned to capture discussions between the teacher and one specific group.

Finally, a sharing session was recorded where the small groups joined together for a large group discussion to share their strategies or ideas on the problem. The video-recorded data became a permanent record and was readily accessible for subsequent review or analysis. Viewing the video footage following the lesson provided the researcher and the teacher participant with opportunities to validate interpretations of students' responses and the teacher's actions made during instructional activities.

Although video is a valuable vehicle for gathering and storing data, it is not flawless. The introduction of the video camera in a classroom may cause changes in the ways participants interact and behave. To minimise undesirable effects caused by the video recording, the teacher explained and discussed the purpose of taping and modelled the normal routines and behaviour expected when engaged in mathematical inquiry before formal observation commenced. Furthermore, observations were made during three lessons a week at the start of the project, followed by every fourth week until the end of the project and involved 15 lesson recordings. This supported the gathering of more representative data as described by Yin (2012).

Transcribing the video-recorded lessons supported the researcher to reflect retrospectively on what had occurred during the observation in relation to the research questions. The emerging themes and patterns from the data were then matched against the theoretical framework.

Detailed field notes are used in qualitative research to supplement as much information about the complex interactions in the classroom as possible (Yin, 2012). Written commentary on teacher actions, student actions, board work and materials used, were recorded promptly during and after each observation by the researcher. These field notes were incorporated in the lesson transcripts in brackets to document an accurate account of events from all angles that were not captured by the video-recorded observations.

3.5.2 INTERVIEWS

In qualitative research, interviewing is a common means of collecting information in the participants' own words (Berg & Lune, 2012). Interviewing is necessary to understand what is on "someone else's mind" (Merriam, 1998, p. 76) and enter the world of the participant (Merriam, 1998; Yin, 2012). In the current study, interviewing was used to clarify the reasons for the instructional activities, teacher actions or student responses, and to investigate a potential explanation for a specific comment or behaviour. In the study, discussions with the teacher were conducted immediately prior and post each lesson. The goal was to explore the content of the lessons and also the culturally responsive practices the teacher used to support the Pāsifika students to meet these goals over time. The data from the interviews provides an important description of both the teacher and the students' perspectives about mathematics learning in the classroom. The interviews with the fifteen students were conducted after the study to explore how they interpreted the role of the teacher in the learning process. The interviews with the students were about 10 minutes in duration for each student and were audiorecorded to allow a less intrusive method of recording data. Field notes were taken during the interviews to supplement recordings.

The interviews followed a semi-structured format (Appendix, A) which allowed the researcher to respond to the "emergent worldview of the respondent, and to new ideas on the topic" (Merriam, 1998, p. 76). Data gathered from interviews was triangulated with evidence from fieldnotes and the classroom observations. This strengthened the validity of the data generated from the interviews.

3.5.3 CLASSROOM ARTEFACTS

As part of the data collection in this study, student's written work and digital photos of mathematical representations on the whiteboard using diagrams or materials were collected. This collection of artefacts complemented other methods of data collection.

A research field log was maintained by the researcher to record reflections during each stage of the study such as entering any potential emerging biases, assumptions and interpretations of events or interesting events that unfolded that were relevant to the study. These were supplementary to the focus of the study and were another means of triangulating the data.

3.6 DATA ANALYSIS

The purpose of analysing data is to make sense of it (Merriam, 1998). Analysis of data in the current study meant making sense of the teacher's culturally responsive practices to support Pāsifika students to engage in mathematical discourse. Data analysis began with organisation into manageable units with codes that match emerging patterns (Merriam, 1998; Newby, 2014; Yin, 2012). Both the coding used in Hunter's study (2007) to characterise teacher actions and the questioning techniques described by Boaler and Brodie (2004) in their study were drawn upon during the initial data analysis. For example, the coding categories such as "provides wait time for other children to ask questions", "emphasises the value of working together" (Hunter, 2007, p.164) and "exploring mathematical meanings and/or relationships" and "inserting terminology" (Boaler & Brodie, 2004, p. 4) were used to form descriptive codes for the initial data analysis. Data collection and analysis evolved continuously through the three phases of data collection that shaped this study.

Data retrospectively analysed outside of the classroom involved the identification of categories and themes. The transcripts from video and audio recordings were read and re-read to develop potential broad themes which formed the initial categories (See Table 2). These broad themes became the headings of the findings chapter. Further coding was refined and reduced to

sub-categories which narrowed the coding and analysis for close description of the teacher's actions. Each theme was examined and matched against the whole range of data collected including transcripts, field notes, written work samples, and artefacts.

Table 2. Initial coding categories and sub-categories

Initial coding categories of teacher's action	Sub-categories of teacher's action
Gives individual thinking space/time to structure thoughts	Respect silences, give time/space to compose self/understand the tasks
Elicit prior knowledge/connect cultural experience	Connect with home, church or community experience
Rehearse ideas with peers/small group in a safe way.	Encourage think-pair-share, swap student roles in scribing/contributing
Orient to what is understood	Model active listening, invite alternatives / extend potential ideas
Foster safe to take risk learning environment in a culturally sensitive way	Endorsing mistakes are part of learning/discovery of new knowledge
Model an action of what to say in a culturally responsive way	Model polite exchange of words eg. "You can say, I'm not sure, can you ask someone else please?"
Give voice to a quiet member to be culturally inclusive	Ask students to repeat a statement or read the problem
Striving for mathematical language/insert terms	Encourage the repeat use of mathematical terms in student voice
Incorporate cultural belief of collective responsibility	Emphasise the responsibility for themselves and the family
Using body cultural tools/language	Use drawings, students' words, facial expression and hand gestures
Questioning and prompting for mathematical understanding	Press for clear, logical mathematical explanation and justification
Revoicing/seeking a response to agree/disagree	Encourage students to revoice ideas in own their words
Connecting to big mathematical ideas	Reflect on key mathematical ideas

3.7 VALIDITY AND RELIABILITY

Qualitative research needs to ensure the validity and reliability of the findings. Validity is concerned with the honesty, richness, and scope of the data. It is gained through detailed descriptions and systematic measurement (Newby, 2014). Internal validity looks at the credibility of findings and whether the interpretation of an event can be sustained by the data. In the current study, internal validity was achieved by the prolonged period of observations, comprehensive field-notes, and triangulation of multiple sources of data. External validity concerns the transferability of data, that is, the degree to which results can be generalised to other settings (Newby, 2014). The provision of rich and in-depth descriptions of the teacher's culturally responsive practices that support Pāsifika learners in mathematical discourse established external validity.

Reliability is concerned with the accuracy and comprehensiveness of the research. Complex and diverse classrooms pose difficulties in fulfilling the traditional notion of reliability because there will never be any two classrooms where the conditions of learning and teaching are identical (Burton et al., 2014). Lichtman (2013) claimed that it is more appropriate to view reliability as the trustworthiness of the data, the fit between what is recorded as data and what occurs in the setting under study. In the current study, the trustworthiness of the findings can be established by the use of triangulation of multiple sources of data because the wider and deeper perspectives help to safeguard against bias from collecting only one form of data.

3.7.1 *Limitations of Case Study*

Some of the criticisms about case study research are that it is too particular; the sample size is too small and that the results cannot be generalised (Berg & Lune, 2012; Merriam, 1998). In contrast, Flyvberg (2006, in Lichtman, 2013) argued that conducting case studies is valuable because it is a systematic way to produce exemplars in any discipline and "a discipline without exemplars is an ineffective one" (p. 94). Ruddin (2006, cited in Lichtman, 2013) noted that in

some instances case studies can be generalised (p. 797). Furthermore, Yin (2012) claimed that findings from case studies can be generalised but on “analytic rather than statistical grounds” (p. 177). This means case studies can be generalised to other situations on the basis of analytic claims to inform the relationship among a particular set of concepts, theoretical constructs or sequence of events. This study alone is not sufficient to generalise a theoretical construct on how teachers support Pāsifika students to engage in mathematical discourse in culturally diverse ways. However, the findings of the rich dense data in this classroom may be transferable across to similar settings for future studies.

Another concern about case study research is that the researcher may let personal beliefs and biases affect the interpretation of findings (Berg & Lune, 2012; Yin, 2012). Some critics maintain that rather than accounting for or eliminating sources of bias, it is more appropriate to identify and acknowledge factors which may impact on the researcher’s interpretation of data (Burton et al., 2014; Lichtman, 2013). In order to maintain objectivity in this study, detailed field notes and constant reflective monitoring of the researcher’s own assumptions, beliefs and biases were used throughout the study. Objectivity was further enhanced through discussion with participants to clarify the interpretation of findings, the triangulation of multiple sources of evidence over a period of time and by asking the teacher and research supervisors to give critical feedback on emerging findings.

3.8 ETHICAL CONSIDERATIONS

This study followed Massey University’s code of ethical conduct for research, involving human participants (Massey University, 2000). The ethics of social research focus on the need to protect all participants from possible harm. It also includes showing respect to participants with informed and voluntary consent, confidentiality, truthfulness, and social and cultural sensitivity. Ethical approval was obtained prior to data collection. All participants involved in the study were provided with the relevant information to give their informed consent (See Appendix, C,D,E). This research involved children under the age of fifteen years

old, therefore consent from their parents or guardians was also sought and obtained.

It is important that anonymity and confidentiality is guaranteed and that privacy is neither invaded during a study or once the research is complete (Berg & Lune, 2012). Regarding anonymity, the researcher was cautious during filming to ensure that unintentional filming of students who had not consented to participate in the study did not occur; if it occurred, however, the researcher was ethically bound to ensure that none of the footage was used as part of the study and was destroyed.

Anonymity and confidentiality are key ethical issues (Newby, 2014). Although, all participants in this study were allocated pseudonyms, assuring anonymity and confidentiality could not be guaranteed given that the staff and students in the school community knew who the participants (teacher and students) in the study were. However, particular care was taken to exclude any identifying information about the teacher, students or school within any written reports.

Harm to the teacher participant was observed and minimised through open and honest discussion. Potential harm to students was reduced given that the research was undertaken during the normal classroom programme and practice. Potential harm to the school was curtailed by the absence of any identifiable information in reporting.

Sensitivity to social and cultural issues was observed at all times by the researcher such as maintaining the daily opening and closing prayers, the classroom routines, the social groupings selected by the teacher, the preferred language or explanation used by students or the teacher participant, respecting the silences during interviews and terminating observations or interviews when participants appeared anxious or upset.

3.9 SUMMARY

A qualitative research model using a single case study was selected as the most appropriate method for this study. In order to examine how a teacher uses culturally responsive practices to support Pāsifika students' engagement in mathematical discourse, multiple sources of data were collected by the researcher. These included classroom observations which were filmed and transcribed, interviews that were audiorecorded and wholly transcribed, reflective discussions with the teacher, detailed field notes and classroom artefacts. To preserve the reliability and validity of findings, the researcher conducted the study in a consistent and honest manner at all times. Data collection and analysis were carefully reviewed, cross-checked and documented. Ethical principles were upheld at all times throughout this study to ensure that no harm would come to any of the participants. Sensitivity to social and cultural issues was respected and observed by the researcher. The findings and discussion of this study are reported in the following chapters.

CHAPTER FOUR – TEACHER ACTIONS TO SUPPORT PĀSIFIKA STUDENTS’ ENGAGEMENT IN MATHEMATICAL DISCOURSE

4.1 INTRODUCTION

The literature review drew attention to research focused on the specific teacher actions which foster engagement in mathematical discourse. Evidence from research studies demonstrates how through the enactment of socio-mathematical norms, students are able to build positive mathematical values, beliefs and gain autonomy as learners of mathematics. Also highlighted was the significant role the teacher takes in leading shifts so that students become active listeners and participants ensuring productive mathematical discourse and collaborative interaction occur. In this chapter, the findings of the research study highlight the key teacher actions required to develop social norms and socio-mathematical norms to engage students in mathematical discourse in a culturally responsive way.

Section 4.2 examines the culturally responsive teacher actions which were used to develop productive mathematical discourse. The construction of a safe learning environment to support the development of mathematical explanations is also explored. Section 4.3 illustrates how the teacher utilised built cultural contexts and the home language to engage students in mathematical talk. Finally, Section 4.4 focuses on how the teacher facilitated group collaboration processes—aligned to mathematical argumentation—through the cultural values of collectivism and communalism.

4.2 CULTURALLY RESPONSIVE TEACHER ACTIONS TO DEVELOP PRODUCTIVE MATHEMATICAL DISCOURSE

Productive mathematical discourse requires students to be active listeners and participants. However, at the beginning of this study it was apparent that the cultural shaping of this group of Pāsifika learners had resulted in them perceiving the act of listening without questioning as integral to learning. Initially, this meant that whole class or large group discussions were

characterised by long, unproductive silences and polite listening to the teacher. When asking questions the teacher was typically positioned by the students' silence or short answers. When the students engaged in small group work, the mathematical interactions they used were predominantly unproductive forms of talk. As an example in lesson one, a student explained his choice of solution to three of his peers as: *"Because I like it"*. Likewise, during group work when questioned about solutions, the group members responded with unproductive comments and admonished others with comments like: *Just be quiet and listen*. The cultural norms that the students drew on from their home situations were different from those they were expected to engage in at school.

New norms of communication within the mathematics classroom were needed. To do this the teacher worked closely within the culture of the students to develop their voice to explain their mathematical reasoning and develop questions about other student's reasoning.

4.2.1 CONSTRUCTING A SAFE LEARNING ENVIRONMENT TO SUPPORT THE DEVELOPMENT OF MATHEMATICAL EXPLANATIONS

To shift the norms towards a safe learning environment, the teacher drew on actions which included consideration of cultural aspects (e.g. silence, listening to the elders without questioning) while pressing the students towards taking risks in talking and engaging mathematically. For example in lesson two, the teacher quietly sat down and joined the students at their level as they worked in a small group:

Mr J: *So, what did you guys talk about?*

Silence (seven seconds).

Mr J: *What do you guys talk about when it comes to filling up the car, Ana?*
(Inaudible.)

Mr J: *Getting petrol.*

Providing thinking space and time

Through the actions of providing extended wait time, allowing silence, and listening closely to almost inaudible responses, the teacher acknowledged that what he was asking these students to do might not sit comfortably within their previous patterns of interactions. At the same time he showed an understanding that what he was asking these students to do in responding to him as an elder also caused conflict to their values as Pāsifika learners and therefore he accepted silence as an appropriate response. However, he needed to shift them towards behaviour which would support them to engage more actively and so he probed further:

Mr J: *OK, what about Lipe, what did you guys talk about?*

He accepts silence (seven seconds) again before prompting: *Share what you guys talked about, there's no right or wrong answer.*

After five seconds of continued silence he tells them: *It's OK to say I can't remember, can you ask someone else...?*

Modelling explicit ways to explain

In these initial stages the teacher's goal was to have students contribute and participate in ways they felt comfortable and safe. At the same time he increased the press on their need to be able to talk in mathematical ways to explain their reasoning. For example, in lesson two he explicitly scaffolded how they were to provide an explanation: *Talk about what you were doing and say I chose this number or strategy because.* He outlined not only how explanations needed to make sense for the class members who were listening but also how listeners needed to make sense of the explanations offered by others.

Mathematical explanation gradually became an explicit goal for the students. In the post-study interviews, the students described explaining as important not only because it helped them to "*understand how others got it*", but also as a learning tool to "*bounce ideas*", "*learn new things*" or "*bigger ideas*". It was equally important to some students because it helped them to build their "*reasoning*" and to "*argue what is right and wrong*". These student responses

would not be so forthcoming without the successive and explicit learning opportunities afforded by the teacher.

Use narration as a bridge to explanation

When students faltered the teacher drew on their cultural resources to initiate and encourage them to provide a mathematical explanation. For example, in the following episode during lesson four a student, Ani, hesitated to explain. The teacher then prompted him to narrate what he understood within the context of the problem in his own words: *Tell me the story, if you can't tell me mathematically, tell me the story.*

In response Ani contextualised the explanation:

Once there was a little girl called Lina. She was making corned beef with cabbage. She was using the leftover corned beef from Mele. The can of corned beef was six kilograms, so we converted it into six thousand grams. We knew that Mele used eighteen hundred grams. We took away three tenths of the can. We knew three tenths was eighteen hundred. So there will be seven tenths left because seven tenths and three tenths make a whole. So seven tenths will be...

The rest of the group attended closely to the story to the point that it became a shared narration when Jae, another group member, continued the explanation: *Four thousand two hundred grams because adding eighteen hundred together makes six thousand grams.*

Within the above exchanges we see evidence of how the students began emulating the teacher's model of explanation alongside the developing norms of collaboration between group members.

Use turn-and-talk

Another strategy the teacher used to build the students' capability to explain their mathematical reasoning was the use of 'turn-and-talk'. Before launching a

problem he would often instruct students to share their thinking. For example in lesson four: *I would like you to think about fractions and then turn to the person next to you to share the ideas what comes to your mind.* His action gave the students time and space to rehearse their explanations with a partner before sharing with the whole class. Such actions indicated that he recognised that the students were unaccustomed to talk in the formal classroom mathematical setting and they needed to be carefully socialised into appropriate ways of talking mathematically.

Questioning as a sense-making tool and modelling active listening and questioning

Not only was the focus placed on students being able to provide mathematical explanations, the teacher also emphasised the importance of questioning as a tool for sense-making. He recognised that being required to ask questions posed risks for these students and so he emphasised that they needed to be focused and respectful.

Mr J: *Asking valid questions helps us understand what others are thinking...
What are some questions you may ask to help you understand?*

Jae: *How do you know that sixteen dollars and seventy multiplied by six equals eighty-three dollars fifty?*

Mr J: *Thank you Jae. What else can we ask?*

Met: *Why did you do that?*

Mr J: *Yes, so you can use words like: why did you use this strategy and not.....? What else?*

(Lesson 3)

The teacher continued to explicitly focus on expectations for students to engage in active listening when working with a partner or in a group: *When your partner is talking you need to listen and think about what he or she is saying. Ask questions if you don't understand. When it is your time to talk, you need to speak clearly and politely so your partner understands.*

The press to be actively engaged in listening and analysing the reasoning being offered by others was consistently maintained and monitored in every lesson. For example, in an interview after lesson 3, the teacher explained why he had focused on specific students to repeat and revoice what was being explained: *The reason I tried to get Lipe to listen and respond was because I didn't think she understood what was being said, or the idea we were trying to convey.*

Then, he continued to share his observation that she had not contributed to her group's discussion: *She was being a passenger, focussing on what was going on around her instead of participating and asking questions and trying to understand what her group was up to.*

The teacher's actions clearly demonstrate his awareness that active listening and engagement needed consistent monitoring if all students were to participate in the mathematical discourse.

Valuing diverse and collective ideas of students as learning resource

While the teacher highlighted the expectation of active listening, he extended beyond this to an expectation that students would actively engage with the reasoning used by those explaining. For example, during lesson four after recording collective examples of students' understanding of fractions (e.g. equal sharing, the denominator, the numerator, parts of a whole, division), the teacher publicly acknowledged the contributions made by individuals or group members and affirmed the power of collaborative learning: *It is important we are able to share what the problem is and be able to share different ways of working, because we've got ten people sitting here to drive our learning, ten different brains. Everybody looks at something differently, everybody does things differently.*

The teacher used the collective knowledge of the students as a resource to widen the mathematical understandings. Each lesson ended with the teacher probing to make the students connect to the bigger mathematical ideas. For example, after the students had completed a problem and the groups had explained their reasoning, he focused them on exploring different fractional

number representations and expected students to use appropriate mathematical terms.

Using explicit language to connect to bigger mathematical ideas

The teacher gave students opportunities to make mathematical connections between ideas while drawing out the specific terms used in the lesson.

After a whole class sharing session, the teacher invited reflection on the key mathematical ideas.

Mr J: *What are some of the big ideas on this pizza problem?*

Pai: *Convert percentages because it's out of one hundred.*

After writing a summary of the response, the teacher then draws the focus to another key mathematical idea.

Mr J: *One hundred is the link to what?*

Ben: *To a whole.*

Gen: *Converting fractions.*

Mr J: *What have we converted to?*

Ben: *Fractions and decimals into percentages.*

The teacher revoiced and probed further until he heard the students describing the relationship of fractions as part of a whole.

Mr J: *When we think of decimals and convert them into percentages, what kind of knowledge do you think we need?*

Cila: *A fraction is a part of a thing.*

Mr J: *So this is another thing we need to know - fractions are parts of a...?*

Class: *Whole.*

(Lesson 10)

The teacher's actions here in scaffolding students' explanation while using specific terms were important to consolidate mathematical ideas. This

enhanced the students' conceptual understanding and their confidence to communicate ideas in mathematical ways.

The teacher used a range of talk moves to increase student reasoning and to ensure that the students understood the changed norms for participation being enacted. This included revoicing and repeating. For example, during lesson four in a discussion about the need for group understanding he asked why understanding was important:

Students: *Make sure you understand.*

He revoices their statement and then asks why it is important:

Ana: *If you don't understand you don't know what others are talking about.*

He then uses the repeat talk move with a number of students until he is satisfied that they have understood what is required:

Mr J: *Ok, could you repeat that please Ana?*

Ana : *If you don't understand you don't know what others are talking about.*

Mr J: *Ok, Brad, can you repeat that please?*

Brad: *If you don't understand you don't know what to do.*

His persistence in asking the students to repeat the statement emphasised the importance he was placing on both reasoning and their need to participate in the reasoning.

4.3 BUILDING ON CULTURAL CONTEXTS AND THE HOME LANGUAGE TO ENGAGE STUDENTS IN MATHEMATICAL TALK

In order to support student engagement in mathematical activity the teacher embedded tasks within known cultural or social contexts of his Pāsifika students. These included activities which are important to Pāsifika students (for example, church or family celebrations). He explained his use of cultural

celebrations as a site to construct realistic mathematical activity: ...*another popular cultural situation is ula lole, the ceremonial lolly leis that are given out at a celebration or graduation which consist of a mixture of chocolates or lollies, and in some cases money. Students need to buy in that mathematics is real and it is in their everyday lives* (Teacher Interview post lesson 2).

The impact of the teacher's actions in designing culturally relevant tasks was reflected by a student who stated: *It's great to see questions showing our cultures and not Palangi's (English) all the time.* His use of problems which connected into their 'lived world' acted as a motivational tool and the students stated that it was something they could "*concentrate on*" because the mathematics seemed meaningful to them. One particular student remarked, "*It was impressive to see our cultures in the questions because most teachers use English only*". This contrasted with their previous school mathematics experiences of textbook questions with English names and cultural contexts which they could not relate to.

However, in recognition of the diversity of Pāsifika peoples Mr J also tried to ensure that all students were able to access the mathematical task through launching problems in a deliberate way. Before the students moved to solve a task he would discuss any unfamiliar contexts or ideas in the problem. In a post lesson three interview, he explained "*it is important to elicit students' prior knowledge and to make a connection to the problem*". He also considered that the task needed to be relevant if the students were to solve it: *there is no point giving them a task and they don't know the purpose; there has to be a purpose for these students to undertake something. If not, it's not going to mean anything to them. If it's not purposeful, they are not going to make a connection of any sort* (Teacher interview post lesson 3).

Many of the students were English as an additional language learners. Positioned by Mr J as experts within their culture, they were required to translate explanations made by students using their home language and talk about and explain cultural concepts so that all of the learning community understood. In lesson three, he asked a Samoan student to translate the word Sunday feast into Samoan and talk about its meaning to make the context

relevant for all the students: *Tona'i pronounced as Kona-a –ii, which is just like a Sunday lunch.* Mr J then emphasised the importance of the students drawing on their home language as part of the mathematical discussion: *Thank you, you can talk about this problem in Samoan or your home language so you can have a better understanding.* Through his statement he was modelling his understanding of the need for students to use whatever language they considered comfortable and provided them with a richer way to engage in mathematical talk. In this way he was ensuring equitable access to the mathematical activity. Giving learning space or options for students to use their own language in class to discuss mathematics showed the teacher's affirmation of students' cultural heritage, knowledge, and experiences.

4.4 BUILDING GROUP COLLABORATION PROCESSES THROUGH USING COLLECTIVISM

The teacher knew that his students came from homes in which the concept of family was strong and that they were represented in the grouping as members rather than individuals. Throughout the study, the teacher drew on the cultural norms to enact social norms around the concept of families. In addition, he extended the Pāsifika values of respect and collectivism to enhance collaborative discourse and ensure that the students were respected, valued, and heard. He explained the importance of nurturing a home-like environment when he stated: *I want the students to feel comfortable in the classroom, as if they were at home, to learn maths and talk about their ideas freely* (Teacher interview post lesson 2).

The teacher drew on the cultural values of the students and used these to engage them in discussions about their dual responsibility of sense making for themselves and ensuring that others were also supported to sense-make:

Mr J: *When we do maths, there are two responsibilities. What is the first responsibility?*

Students: *Make sure you understand the maths.*

Mr J: *What is the second responsibility?*

Students: *Make sure everyone understands the maths.*

(Lesson 4)

The responsibility to support others to sense-make was embedded within the Pāsifika students' understanding of what it meant to be a member of a collective. To ensure that every student knew they were included, the teacher included the different names for family across a range of Pacific Island nation's languages. This worked to embed the way in which they were bound by their culture to serve others for all the students.

Mr J: *What type of group are we?*

Tin: *We are a family.*

Mr J: *Family, whanau, what's the word for family in Samoan?*

Students: *Aiga.*

Mr J: *Aiga. What's the Tongan word for family?*

Students: *Famalii.*

Mr J: *Famalii. What's the Cook Island word for family?*

Students: (Mumbled.) *Not sure.*

Mr J: *I think it is fanau. Anyway, what do families do?*

Students: *Take care of each other and help each other.*

Mr J: *Take care of each other...*

(Lesson 5)

The concept of family was used as a bridge to build connections between the culture at home and school as well as to shape the social norms of interaction: The teacher explained: *One of the biggest things, or the norms that I established, is that we are a family. The concept of family means to say that we are in this together. If someone doesn't understand, we are there to help her or him. Just like the context at home: if you struggle with something at home you*

ask a family member to help and build on that. That's how we work in the classroom. There is no one leader in the group, in some cases, some students take a leadership role and when they see someone's struggling, they'll help, it's about the reciprocal learning, the sharing of ideas, ensuring they understand before they carry on the task (Teacher interview post lesson 6).

The strongly embedded cultural value placed on family and the collaborative responsibilities the students knew they held within a family was used by the teacher to ensure equitable participation in small group work. This became more evident when he observed a lack of collaboration. For example he moved alongside a small group as they worked and listened closely and then he started to question them about their notation. They responded by directing his questions to the student who had written it. Rather than continuing the discussion with the student who had notated the group solution he said:

What I'm seeing in this group here is you are depending on Seta and yet you are all supposed to be contributing to the conversation. You don't say to the person who scribed "Why did you write this?" It is about being in a family and understanding what is going on. So anyone in the group can say, "Oh, we did this because. This idea is everyone needs to understand. I'm sorry for Seta because everyone put her on the spot. She did lots of working and it is supposed to be five people together. The idea of working in the group is to bring all of you together so that you all have a common understanding. If something doesn't make sense to you, ask questions.

(Lesson 6)

This illustrated the way in which the teacher consistently reinforced the need for collaborative interaction and shared ownership of mathematical discourse and reasoning. But he did this within the cultural norms of the students where collaboration really did mean a shared endeavour. His use of the metaphor of family illustrated the way in which he respected their cultural values and used them to shape the classroom norms. In turn the students responded positively

and when asked seven students (n=15) described how the teacher used the idea of the family to support their learning. One student stated: *Mr J told us to help each other in learning maths, just like we help our brothers and sisters at home.* (Student interview post lesson 13).

Group norms were established which focused on the need of all students to collaboratively support each other and contribute. For example, in lesson five during a discussion of fractions the teacher placed emphasis on the use of the words “**we**” and “**us**”: *It is important for **us** because **we** want to find out what the whole class knows about fractions. You can start with “I think...” so that **we** don’t have any passengers here, **we** want everyone to be drivers, everyone talking.* This example illustrates how the teacher emphasised individual student responsibility to drive their own learning while also their responsibility to contribute and drive the whole class’s learning. The use of “*I think...*” allowed students unused to contributing to have a tentative voice and begin to learn to explain in a supported way.

The students in this classroom had positioned the teacher as an elder who within a Pāsifika community would not be questioned. To construct a productive learning community the teacher worked to reposition himself as a member who was available to interact with more easily in the community. This included sharing his own ideas during group discussions and empowered student voice to help others understand. He showed this when he said: *In some cases, also, if someone doesn’t quite understand what I said, a student can say the exactly the same thing and all of a sudden, they understood. One of the members of the group can clip on to what is required and scaffold from there* (Teacher interview post lesson 8).

He directed student attention to those students who modelled appropriate behaviour which supported group learning. For example in lesson three when a student made a recording error and another group member stepped in to clarify the error the teacher said: *Thank you Ana for your help in clarifying here. This is what I mean by getting the help from your group.*

Collective responsibility was also enacted when student errors emerged in mathematical activity. For example in lesson three, during a whole class discussion, a student explained her solution strategy. Part of her explanation contained an error which was challenged by another student. In response the teacher neither confirmed nor denied whether the solution was correct, instead he qualified the need for further discussion and explanation.

Mr J: *Why do you disagree? You need to come up and write. Show us why you disagree.*

When the student provided an alternative explanation the teacher turned to the class and asked them to use their own reasoning about the alternative explanation

Mr J: *What do you think? Did you agree with Ben? Why?*

This provided the original explainer with space to reconsider and reconstruct her reasoning within a respectful environment.

Ana: *I know where I've gone wrong, it's sixty litres and not six!*

The teacher then affirmed the value of errors as learning tools.

Mr J: *It's OK, sometimes, it is not until we put things together, we realise where we went wrong. Those mistakes help us make those discoveries and they help us learn more.*

Respecting students' errors as learning opportunities

In the example above, Mr J illustrated that errors are valuable as reflective tools to learn mathematics. He also showed that making mistakes is part of what it means to do mathematics within a learning community and that it is the responsibility of all members to work through and contribute to reflective reconstruction of reasoning.

Through these actions the teacher drew on students' known ways of working within Pāsifika culture. Collectivism and learning from each other were being

fostered rather than individualism where each person is only responsible for their own work. He showed the value of the students' diverse perspectives and clearly highlighted the importance of learning from each other's ideas.

4.4.1 INCREASING THE PRESS TOWARDS MATHEMATICAL JUSTIFICATION AND GENERALISATION

Being able to disagree in ways that are culturally appropriate was an important norm to establish. To develop students' confidence to argue mathematically, the teacher explicitly focussed on their need to disagree and provided models of ways to do this. In the following example we see how the teacher began mathematical activity with a discussion which challenged them to think about not just agreeing but also disagreeing:

Mr J: *What if you don't agree?*

Met: *You ask them why...why did you do that?*

He also provided models of ways to disagree.

Mr J: *You can say: I'm not sure about that bit or I'm not convinced about that part. Can you convince me or show me another way so I can understand. You need to say that when you disagree and are unsure about that part.*

(Lesson 4)

At the same time he recognised their discomfort when they needed to disagree and so he directly addressed the behaviour he observed they used to avoid disagreeing: *You don't look around, play with your pens and tune out, you need to ask those questions and know what is going on.* His statement validated their discomfort while also letting them know that he expected them to work through it.

Often the teacher was seen to draw on students' cultural understanding of family as a safe way for them to engage in what he termed "friendly" arguments. His prompts to agree, disagree, and challenge through questioning were all

prefaced by their safety to do so within the family community in the classroom. He explained: *Again, it comes back to the family/whanau concept, when it comes to the questioning (Teacher interview post lesson four).* However, constructing a safe environment to engage in questioning was not sufficient—he also wanted the questions to be well thought out mathematically so that the students could access reasoning used by others. He explained: *“They need to think about the questions before they ask them. I notice at times when the students ask ‘Where did you get the six from?’ The obvious thing from the question they need to think about is what they want to know prior to asking the question. If something doesn’t make sense they need to think about what doesn’t make sense so that they can basically pinpoint ‘I’m not too sure what is going on there, can you explain that bit to me?’”*

(Teacher interview post question 9)

As part of developing the skill to agree or disagree with reasoning, gestures were introduced. For example in lesson seven, during a discussion the teacher asked: *Do you agree with that? Who agrees with the statement? Show me a thumbs up. Disagree?—Thumbs down. If you are not sure or do not understand, your thumbs go sideways and you need to ask questions.* The development of a classroom mathematical community inviting students to use gestures to show their reasoning was an inclusive way to get all students participating. It also gave an indication to those students who were unsure that giving no response was not accepted and that a more appropriate response would be to think of valid questions to ask.

As the lessons progressed the teacher increasingly placed an emphasis on the students needing to agree and disagree backed up with explanations in which they provided valid reasons. Discussions were also initiated about what it meant to justify and why this was important. For example in lesson eight, he listened carefully to a student describing why they needed to provide explanations related to justification and then revoiced what they said: *What Pat was saying was that justification is really important because not only you are able to explain*

your answer, you need to explain why it works, when we justify we know it works, the best way to do it is when you prove it.

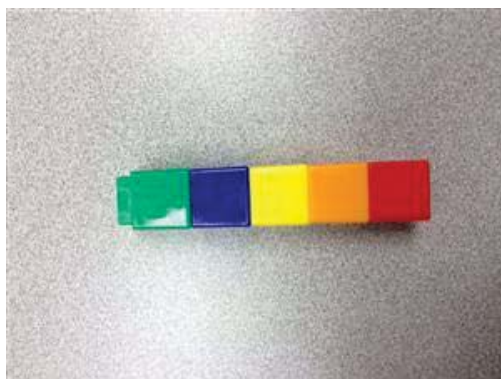
Using materials to support justification

As the lessons progressed, the students began to model the teacher's actions and they in turn began to consistently require justification for other student's statements. For example in lesson ten, the teacher wanted to develop the understanding that surface area is measured in square units. As they discussed the problem in which they had been asked by the teacher to determine the face area of one wooden place value block (in figure 1- each square is 1cm by 1cm) and compare it with the amount of unifix coloured cubes (figure 2- each coloured cube is 2cm by 2cm) needed to cover the wooden block, a member of the mathematics group continued to ask for justification until the explanation the other student was offering was clear.

Figure 1. Wooden place value block



Figure 2. Unifix coloured cubes



Kon: *We know the wooden block is one hundred wooden squares.*

Sone: *I think you only need twenty-five coloured cubes to cover the wooden block*

Jo: *Are you sure? You need to show us how you got that.*

Sone: (Places five rows of coloured cubes on the wooden block)
If you have five coloured cubes across and five down, you get twenty-five cubes – see you can cover the wooden block. You see one colour cube is the same as four wooden cubes. One row of coloured cubes will cover twenty wooden cubes, two rows cover forty cubes, three rows – sixty, four rows- eighty, so, five rows of five cover the whole wooden block.

Positioning students to take the responsibility for their own learning and repeatedly ask questions until convinced led to many of the less confident students accessing reasoning at a high level. For example, Lipe at the beginning of the study had often been quiet or disengaged. However, later in the year she became persistent in wanting to understand and would question until she knew she did. For example, in lesson fourteen the students were presenting a solution strategy for a problem² and Kua began by recording on the whiteboard: $20\% + 20\% + 20\% = 60\%$, the remaining cheese pizza is 40%. He then states what is left:

Kua: *The remainder of the pizza is forty per cent.*

Lipe: *How do you know the remainder is forty per cent?*

Pai: *Because it makes one hundred per cent.*

²At the end of the term N1 has decided to have pizzas for their shared lunch.

The class selected 3 people to be responsible for choosing the toppings for the pizzas. Caroline orders 1 pizza, she asks for 20% bacon, $\frac{1}{5}$ chicken, 0.2 salami and the remainder cheese. What portion of the pizza is cheese?

The teacher noted that Lipe has not yet made complete sense of the explanation then asked the group to write it as an equation. In response, a student wrote on the board $60 + 40 = 100$ and drew a circle marking the proportions as he explained: *Here we have sixty per cent, the whole is one hundred, so sixty and forty is one hundred.* At this Lipe said emphatically: *OK, I get it.*

Engaging students in explicit discussion about the need to justify reasoning was also a means for the teacher to consistently address their reticence to ask difficult questions and challenge the reasoning of other's. He stated: *The attitude with the students is that they are not there to catch them out about their wrongs. They are arguing so that they can justify their reasons why they selected a strategy or use the strategy. When they justify, they would say, I use this strategy because..., they justify when they reason why, in most cases, the other members of the group would develop a better understanding, they start seeing the bigger picture and start connecting with the big ideas. Again, the mathematical argumentation is about the maths, not trying to catch someone out it's about they can get a better understanding of the whole process.*

(Teacher interview post lesson 9)

The teacher also introduced a press for the students towards generalising their reasoning. For example in lesson six, during a discussion about the need to understand the importance of a unit in solving a problem involving finding the fraction of what was four fifths of four hundred and twenty five grams of corn beef he began with questions which pressed for reasons:

Mr J: *Why do you think it is important?*

Pela: *Because we need to find one fifth so that we can find three fifths or four fifths.*

Mr J: *Are you saying, without finding one part first, you can't find three parts or four parts of something. So the essential part of that equation in regards to both parts of the problem was that you need to ensure you find that one fifth, that's what one unit equals to. Do you think you could solve this problem without knowing what one fifth is?*

All: No

Recognising that the students were in agreement about the importance of finding one part of a fraction the teacher then pressed them to make connections to other mathematical concepts:

Mr J: *I wonder if it works every time to find out one unit first.*

This resulted in a student voicing a link they could make to a previous mathematical problem and generalising the relationship.

Ana: *Just like the petrol problem. We know one unit of petrol is how much, then we find out what ten units are and so on.*

The teacher's actions illustrated the gradual shift he was making to maintain a safe learning environment. At the same time he was increasing the press for students to engage in rich productive mathematical discourse which involved mathematical justification. The teacher noted the way in which the students appreciated opportunities to construct and reconstruct their understandings when he stated:

Ensuring the norms of listening and everyone has a say or have equitable participation. Some of the students shared that they learn quite a bit from each other, they have set ideas about what is going on but when they hear from others, it starts to broaden their knowledge and understanding of what needs to be done. In some cases, when they don't understand when something doesn't make sense, they will argue because they need the justification, how did that work, why did that work for their peace of mind so they can make that logic. At times, that friendly argument works in both directions. Sometimes, someone may make a slight mistake and they realise and say "oh, I know what you mean."

(Teacher interview post lesson 14)

The consistent focus on all students' responsibility for collaboration in sense making resulted in their increased awareness of their need to provide clear explanations which included alternative ideas to drop back to if needed. For

example in lesson six, the students were explaining their solution strategy for a problem³:

Kon: *We know two-eighths of one hundred and twenty equals thirty. We halved it so a quarter of one hundred and twenty is thirty.*

Ana: (A listening student) *I'm not sure, why did you halve it?*

Sone: *We know two eighths is confusing so we halved it... Because one quarter is an equivalent to two eighths.*

Sone's statement indicated their knowledge that they needed to ensure that other listeners could access their reasoning without any confusion. In order to make sure of this they had changed the fraction to one they considered others would work with more easily.

Making connections across problems was an important development in building the students mathematical discourse and their ability to reason through to a problem solution. Gradually the students gained greater agency as individuals and as a collective. They depended less on the teacher and more on the resources they each brought to the problems they were solving. For example, in lesson nine the students were discussing and working with the following problem⁴. They had drawn a grid⁵ but were struggling in finding the key connection. The teacher approached the group, commended on their effort

³*Mele and Lina each had 120 grams of corned beef to use for their tona'i on Sunday. Mele used $\frac{2}{8}$ of her corned beef and Tina used $\frac{5}{8}$ of hers. How many grams of corned beef did each use? Who used the most?*

⁴*Twelve mamas are working together to make a big tivaevae. Each mama makes one patterned square. Each side of her square measures 0.75 metre. Teremoana has the job of sewing a border around the tivaevae, after all the squares are joined together. What is the area of the tivaevae?*

⁵

Last problem: 10 mamas	Each side of the square is 150cm
New problem: 12 mamas	Each side of the square is 0.75cm

while directing their focus to the task involved: *I can see you've put the information into a grid, well done. So can you tell me the link?*

When he gets a negative response he continues:

What does the square tell you? What information do you know about the square? I will give you some time to talk among yourselves. Just keep going. At this point he walks away leaving the students to draw on their own resources. At first they felt puzzled and lost but they continued to discuss the problem and possible solutions:

Kon: *I know this looks hard... but we know about the difference of two mammas, so what is the link between zero point seven five centimetres and one hundred and fifty centimetres?*

Ree: *What are centimetres and metres again?*

Sone: *One hundred centimetres in one metre (checking the metre ruler).*

Kon: *OK, now looking at the two dimensions...*

Sone: *I think this is half of that (pointing at 0.75m and 150cm).*

Ree: *Half of what?*

Kon: *Yes, one hundred and fifty centimetres is the same as double zero seven five metres. See here (writing $75 + 75 = 150\text{cm}$). Zero point seven five metres is really the same as seventy-five centimetres so when you double that, it makes one hundred and fifty centimetres.*

Clearly, collectively they did have the resources to solve the problem. As they persevered in working out the problem, they questioned and talked together until they all made sense of the problem. The teacher's actions in trusting that they could solve the problem without his directions and the reflective space he provided them with supported this. This was also reflected in the post study student interviews. They described how their teacher helped them to understand the problem, with more than half of the students (n=15) providing

similar comments such as: “*he gave us a clue and time to work out*” or “*he let us ask questions and think - not giving us the answer*”.

Explicit teacher modelling of providing justification for claims and the requirement for collaborative interaction led to shifts in student reasoning. The above vignettes illustrated how students appropriated the models the teacher had provided and increased their confidence to independently ask class members for justification of their mathematical claims. It also illustrated the students' increased confidence in making justification independently.

4.5 SUMMARY

This chapter has outlined the five month journey Mr J and his Pāsifika students took in developing a culturally responsive mathematics classroom. The teacher affirmed Pāsifika students' cultural heritage, language, experiences, and identity to engage them in productive mathematical discourse. He used the value of family to foster social norms that regulated social interactions in class. Similarly, the teacher used the cultural value of collectivism with the students' cultural resources to nurture socio-mathematical norms to support students in mathematical discourse. These norms included the expectation to make reasoned explanations, justification for mathematical claims, developing mathematical generalisations and connecting to big mathematical ideas. Specific teacher actions included making mathematics relevant by incorporating cultural elements in the mathematical tasks, utilising students' home language, modelling culturally responsive ways of asking questions, as well as explaining and justifying mathematical reasoning used by others. Turn-and-talk, repetition, revoicing, manipulation of materials, gestures, and inscription were all useful strategies to widen the mathematical discourse. The expectation of students to use concise mathematical terms in different ways in discourse fostered deeper conceptual understanding.

The significance of the findings presented in this chapter are discussed in the following chapter.

CHAPTER FIVE – DISCUSSION

5.1 INTRODUCTION

The previous chapter presented an analysis of the findings of the current study. The teacher's use of the Pāsifika students' cultural values, language, knowledge, experiences, and identity to support students' participation and communication patterns were illustrated. The evidence has shown that when the teacher acknowledged students' cultures and incorporated their cultural practices as learning resources, Pāsifika students were better supported to successfully engage in mathematical discourse. In this chapter, the findings are discussed and situated in the theoretical framework of the current study.

Section 5.2 discusses the role of the teacher and links the classroom context of the current study to socio-cultural theory and culturally responsive pedagogy. Section 5.3 examines the use of cultural contexts and home languages to support collaborative discourse. The development of a culturally safe learning environment to support mathematical discourse is discussed in section 5.4. Section 5.5 discusses the teacher's culturally responsive actions to reinforce group collaboration and collectivism that enhance mathematical discourse. Finally, a summary concludes this chapter.

5.2 THE ROLE OF THE TEACHER IN CREATING A CULTURALLY RESPONSIVE CLASSROOM TO SUPPORT COLLABORATIVE DISCOURSE

The teacher played an important role in creating a culturally responsive learning environment to support collaborative discourse. The teacher realised that he needed to work within the students' different cultural and social groups for the sake of developing the students' ability to communicate their mathematical ideas. He ensured that they had time and space to talk about the reasoning of difficult and counter-intuitive mathematical concepts such as fractions and decimals. He showed that he valued effort as equally important as getting correct answers; therefore, he encouraged students to participate in the

discussion so that they could initiate their own learning process. His actions aligned with those used by other researchers who have drawn on socio-cultural theory (for example, Goos et al., 2004; Mercer, 2000). Similar to what these researchers illustrated in their research, the teacher in the current study took the stance that when teachers and students work and communicate with each other, intermental development zones are created which afford students the opportunity to explore and take ownership of their own learning.

In the current study the teacher created a learning space that required students to bring in their diverse cultural knowledge and experiences to make sense of mathematics. Embracing and linking the diverse perspectives of the Pāsifika students was essential to their mathematical learning. It also aligned with the notion of “crossing cultural borders” in thought and action proposed by Gay (2010). The findings illustrated how the teacher facilitated the students to share their experiences with fractions, decimals, and percentages. He encouraged the students to verbalise the use of fractions at home and make connections to their everyday knowledge. For example, he elicited from them “*one cup of water to two teaspoon of milo*”, “*one pizza to share with ten people*”, “*three metre of cloth to make two ta’ovala (mat skirt)*”. In doing so, he recognised that the students represented a diverse range of Pāsifika cultures and so he encouraged them to use their cultural knowledge and everyday language to mathematise their lived experiences. 895

The teacher drew on the Pāsifika students’ own voice to support them to create their own communicative style. For example, he prompted a student to explain what he understood within the context of the problem by telling the story in his own narrative. This use of a participatory and interactive communal style was similar with what Au (1993) described as the talk-story or co-narration of Native Hawaiian students in her research. Although, Au’s study was in the context of reading and not mathematics, the culturally responsive actions match and fit well within the use of oracy as a way of learning within Pāsifika dimensions. Within this frame the teacher in this study created a co-narration which involved students working collaboratively or talking together to create an idea, tell a story, or complete a learning task. The collaborative talk that the teacher valued

in the current study aligned with Au's (1993, p. 114) study, where the Hawaiian students viewed "talk-story" as a "group performance in speaking" rather than an individual pursuit in learning.

In the current study, every individual was accountable for contributing to the well-being of each other. The ethos of family and collectivism reinforced the social expectation of collective discourse. The teacher reminded students of their dual responsibilities for making themselves and everyone understand the group thinking. The clear focus of the teacher on building collective discourse through drawing on the communalism of family allowed deeper and richer discourse to emerge. This finding parallels with the work of both Bell and Pape (2012) and Hunter (2010) who illustrated that successful discourse in mathematics learning takes place when the teacher and students hold all other members of the community accountable in explaining and justifying their ideas mathematically.

The teacher drew on and used collaborative discourse as a way to enhance the learning of all the students. He drew on the collective power of the students to make sense of mathematics, even when the students were struggling through a problem, the teacher would urge them to support each other, to persist in solving the problem. He emphasised learning as a collective endeavour and used inclusive language to include pronouns such as "**we**" and "**us**". This is reflected in Bills and Hunter's work (2015) where the teachers used similar inclusive language to drive group learning. In doing so, the teacher instilled the ethos of a caring culture. This meant that even if no one in the group knew immediately what to do, eventually progress could be made when students support each other by asking questions and sharing ideas collaboratively. This finding also aligned with the study by Walshaw and Anthony (2008) that when students work collaboratively on solving challenging tasks, they show a greater level of cognitive engagement than those working independently.

In the work by Noddings (2008), the research argues that a caring culture is necessary for equitable participation of students to take place. The teacher in the current study consistently expected every student to contribute to the

discussion in the small group and carry out their collective responsibilities of ensuring everyone understood each other during mathematics lessons. In doing so, he effectively redistributed the sharing of mathematical authority with all students in the classroom. His actions were similar to those described in other research studies (e.g., Bell & Pape, 2012; Bills & Hunter, 2015; Hunter, 2010; Makar et al., 2015). Rather than adopting asymmetrical positioning (Esmonde, 2009) in which novice students learn from the experts, all the students were positioned as being responsible for understanding others' explanations and for communicating their thinking clearly so that others could learn from them. In this way, students were positioned to fulfil their communal obligation in supporting one another in their pursuit of mathematical learning.

The role the teacher took in the classroom was a contrast to the traditional role often seen in mathematics classrooms where the teacher positions oneself as the authoritative holder of knowledge. Instead the teacher took actions to ensure that the validation of knowledge was evenly distributed across participants. For example, when a student provided an idea rather than stepping in, he required that the group or class consider the idea carefully and make their own decision about its validity. Similar actions by teachers are evident in other studies set within inquiry classrooms (e.g., Goos et al., 2004; Khisty & Chval, 2002; Makar et al., 2015). Through such actions the students and the teacher in the current study equally assumed responsibility to contribute to the decision-making processes about the reasonableness of each group's strategies and the legitimacy of solutions.

Teachers' beliefs and attitudes towards mathematical discourse and inquiry facilitate students' agency towards mathematics (Goos, 2004). By emphasising the value of a joint effort while solving a mathematics problem to contribute new insights, the teacher empowered the students to view themselves as capable learners in mathematics. Similar to the description of teacher actions by Yackel and Cobb (1996) as students negotiated meaning and became accustomed to validating mathematical truths through collaborative discourse, they developed opportunities to become academically independent in mathematics. Furthermore, the teacher in the current study showed his belief in his students'

capacity to be independent mathematics thinkers within their own culture. He extended this to affirming their ability to argue their ideas mathematically in culturally safe ways. This finding is consistent with the findings of Bills and Hunter (2015) in which Pāsifika students were shown to become successful and independent thinkers in mathematics when their cultural knowledge and experiences was acknowledged in the classroom.

The teacher played a central role in scaffolding students' mathematical explanations. When the students struggled to explain their actions or reasoning the teacher provided the appropriate language or specific terms. In doing so, the mathematical thinking became visible and accessible to everyone. A number of studies (e.g., Khisty & Chval, 2002; Makar et al., 2015; Rittenhouse, 1998) showed that when teachers provided explicit language for students, the explanation became clear for others. Similarly, the teacher in this current study provided prompts or a language model for students to use so that they could access the appropriate language to explain their thinking. Often the teacher took on the role of an interlocutor as described by McChesney (2009). He intervened in a more complex student explanation so that the presentation was broken into smaller steps. While this may have slowed down the student's contribution, it provided more time both for the student to gather their thoughts and for others to digest the information given and focus on the explanation.

The teacher in the study purposefully structured a range of types of communicative actions during lessons to support students to develop mathematical insights. He would ask students to turn and talk to a class member or work in small groups to brainstorm, clarify ideas, or discuss ideas from their cultures to explore a topic in more depth. White (2003) explains that some students may be more comfortable to share their thinking with a friend rather than with the whole class. Discussion with peers or small groups allowed the students to individually share their thinking, get support or specific feedback on their ideas and make sense of other ideas. Similar to other studies, (eg., Allen, 2012; Lamberg, 2013) the findings of the current study showed how small group discussion and partner talks could potentially generate rich ideas for a whole class discussion. Recurrently, the teacher found various ways to

incorporate students' cultures into the classroom to maximize the potential of collaborative discourse.

5.3 BUILDING ON CULTURAL CONTEXTS AND HOME LANGUAGES TO SUPPORT DISCOURSE

The teacher in the study designed tasks that reflected the cultural context of Pāsifika students (e.g. making ta'ovala - mat skirt, finding area of tivaevae - patterned quilt). His intention was to make mathematics learning culturally meaningful and through these means motivate student engagement in mathematical activity and discourse. Bills and Hunter (2015) showed similar results. They explain that when the cultural capital of Pāsifika students is reflected in both mathematics problems and activity, not only does it affirm mathematics in their "lived life", but it also validates their sense of normality in their own culture.

Research studies (e.g., MacFarlane, 2004; Tuafuti, 2010) highlight that Pāsifika students feel secure and empowered to learn when their language, culture, and power are valued in the school setting. In the current study, the teacher showed that he valued the diverse cultures of his students and believed it was necessary to bring in their cultural experiences and home languages to mathematics learning. He informed his students that their home activities and languages were important to help them learn mathematics at school. Therefore, he gave his students the right to talk about mathematics in their own cultural context using their own language. During interviews the Pāsifika students revealed positive feelings when the mathematics problems related appropriately to their culture. They were pleased to see that their teacher constructed problems in a Pāsifika context and used words from the various Pāsifika cultures to make mathematics meaningful and relevant to the students' experiences. This finding is also consistent with the culturally responsive teaching promoted by Gay (2010).

A culturally responsive way to create a familiar learning space for students is for the teacher to actively use the students' language as a learning resource (Johnson, 2010). For this reason, the teacher positioned students as cultural experts and made the effort to learn some words from the students' culture. For example, he used *tona'i* – the Samoan word for Sunday feast, *ta'ovala* – the Tongan word for mat skirt, *tivaevae* – the Cook Island word for patterned quilt. His actions sent a powerful message to the students that their culture was relevant and important in terms of learning mathematics.

Similar to the teacher's action in the report by Walshaw and Anthony (2008), the teacher in this study used students' culture to bridge their intuitive understandings with conventional mathematical understandings. He began by asking students to unpack complex mathematics problems by making associations with their cultural experiences and home language to initiate discussion. In this way, students gradually became more confident in their ability to deconstruct problems into their key components, which allowed more insightful comments to emerge. Before students began their independent collaborative work, the teacher ensured any unfamiliar terms or misconceptions were addressed concerning key features of specific tasks (e.g. the difference in meaning between the perimeter and the area of the *tivaevae*). Gradually the students were able to use conventional mathematical terms in a common language that conveyed a shared meaning between students. The need to develop a common language to enhance understanding is consistent with the finding in the study by Jackson et al. (2012).

The teacher in the current study encouraged students to use their preferred language in mathematical discussions. Civil (2014) contends that allowing students the flexibility to discuss mathematics in their preferred language adds richness to the discourse. The students in this study used code-switching between English and Samoan or Tongan to discuss their ideas. Similar to Bills and Hunter's study (2015), when students in the current study started code switching between languages that involved words, phrases or sentences, they were able to articulate meanings that were important to them. This process tended to enhance students understanding as observed by Johnson (2010). In

this code switching process, the students were actively engaged in creating a shared thinking space through the intermingling of ideas articulated in multiple languages, which Lipka and colleagues (2009) describe as a *third space* of intellectual engagement. By providing opportunities for the students to use their own language in class to discuss mathematics, the teacher affirmed the students' cultural heritage, knowledge, and experiences. These are important cultural resources to foster positive student engagement in the development of mathematical discourse and learning (Civil, 2014; Johnson, 2010; Latu, 2005; Moschkovich, 2012).

5.4 CONSTRUCTING A CULTURALLY SAFE LEARNING ENVIRONMENT TO SUPPORT MATHEMATICAL DISCOURSE

For mathematical discourse to take place, the teacher in the study realised it was necessary to create a secure learning platform on which students could communicate, reason, and critique ideas in a friendly environment. One of the first actions the teacher made was to work towards shifting students' cultural view of what it meant to learn in the mathematics classroom. The teacher in this study encountered similar silence with the Pāsifika students in his classroom as Hunter and Anthony (2011) described in their study. The students' behaviour indicated that they believed to learn mathematics they needed to sit and listen to the teacher passively. In the first instance, the teacher in the current study respected what Tuafuti (2010) terms the culture of silence and provided space and time for students to construct their thoughts before being expected to share with others.

The teacher understood that he needed to shift the students from a passive model of learning to one of active engagement. He did not let the students sit and listen passively. Instead, he wanted students to constantly reflect and question others' contributions while listening. He decided that scaffolding collaborative interaction was a key goal. The teacher regularly reinforced the Pāsifika values of reciprocity and belonging to ensure that every student contributed equally to the learning in the classroom. This included the

development of the norm that success in their mathematical learning was dependent on their collective effort in supporting each other. Consequently, group tasks remained unfinished until each member could explain and justify their thinking and acknowledge every contribution made in the group. In doing so, a safe learning space was created that valued the diverse ideas from each person to the group. This reinforced the shared expectation of collaborative work. This finding is consistent with previous studies (e.g., Averill et al., 2009; Hunter & Anthony, 2011; Manoucheri & St Johns, 2006) in which collaborative interactions between group members was a critical part of productive mathematical discourse.

In order for students to have confidence in talking mathematically, they must feel safe in the learning environment before they can feel comfortable enough to take risks. Initially, the students were either passively listening to the teacher or reluctant to share their ideas in classroom discussions. Therefore, the teacher spent time nurturing the development of classroom norms and expectations for productive discourse. He gradually built student confidence by modelling explicit social processes such as active listening, asking questions, and explaining mathematical ideas. This finding is aligned with previous studies (e.g., Civil, 2014; McCrone, 2005) that teachers' explicit modelling of these critical skills paved the foundation for productive mathematical discourse.

The teacher also praised the students who modelled appropriate behaviour in collaborative work while demonstrating the ethos of care. For example in lesson three, the teacher directed the class attention to the expected behaviour that he valued: "*Thank you Ana for your help in clarifying here. This is what I mean by getting the help from your group*". He also publicly acknowledged the individual effort made by less confident students to validate the importance of their contribution to the class learning. This finding reflects the work of Rittenhouse (1998), a researcher who claims that these social norms are important because they become the social norms of learning in a culturally safe classroom. Once students become aware that others are interpreting and acknowledging the contribution to what they are saying, they will put in greater effort to express themselves more clearly and show more interest in sharing their ideas. Similarly

in the current study, the expectation was repeatedly made clear to the students that they had to collaborate as a group in order to successfully negotiate meaning. These explicit teacher actions have been shown to be important in many studies (e.g., Bills & Hunter, 2015; Goos et al., 2004; Noddings, 2008).

Another teacher action that fosters a safe learning environment is instilling the perspective of mistakes as important learning opportunities. The teacher explained the need to respect and support each other's learning. He emphasised that it was acceptable and sometimes necessary to make mistakes when students were learning to solve problems in mathematics. He pointed out to the students that they could potentially learn more from working through mistakes rather than being taught a method to solve a problem. Researchers in other studies (e.g., Hunter, 2010, McCrone, 2005; Noddings, 2008) have shown that when teachers support mistakes as learning opportunities, it fosters greater student participation in sharing ideas. Similarly in the current study the teacher showed that making mistakes is part of what it means to do mathematics within a learning community and it is everyone's responsibility to reflect on the mistakes and learn from them.

The teacher employed an array of talk moves to facilitate students to interact with each other through collective discourse. A range of other studies (e.g., Bell & Pape; 2012; Chapin et al., 2013; Johnson, 2010; Kazemi & Hintz, 2014) have shown talk moves to be effective in developing discourse. For example, turn-and-talk is an effective and inclusive way to get students to share their ideas. In the current study, the teacher frequently used wait time after a question was posed by him or another student. Chapin et al. (2013) contend that giving wait time to students is a way to communicate an expectation that everyone has important ideas to contribute. More importantly, in the current study the teacher gave time for the class to listen to the contributions from other students during large group discussions. He also allowed ample time for students to digest and analyse the information given and construct their thoughts before sharing. This meant that students were able to make richer contributions to the discussions.

This finding aligns with the findings of other studies by Chapin et al. (2013), Gay (2010), and Johnson (2010).

Other key talk moves that the teacher used were repeating and revoicing. In this study, the teacher used the repeating move as a means of fostering active listening. Similar to what Chapin et al. (2013), Lykins (2015), and Johnson (2010) found, in this study the use of repeating as a talk move endorsed the social norm that mathematical ideas shared by classmates are important and should be listened to carefully and taken seriously.

Revoicing was another effective move that the teacher used to shape social norms that supported classroom discourse. Similar to Johnson's study (2010), the teacher in the current study used revoicing to create an atmosphere of openness to guide students into talking freely. As a result, Johnson suggests that students would feel they are able to express themselves without the fear of making mistakes or being corrected for a partially formed idea. As Chapin et al. (2013) explain, revoicing helps to clarify students' understanding and it presents student's ideas in a way that the teacher and other students can validate. It also provides thinking space for students to track what is going on mathematically as the discussion progresses (Chapin et al., 2013). This move allows all students in the class to hear an explanation expressed in a different way either by the teacher or another student. These alternate words or phrases are important to the language development for those who learn English as an additional language separate to their home language (Johnson, 2010). Likewise in the current study, the repeated use of alternate versions of the same concept helped the Pāsifika students not only in terms of advancing their English language skills, but also to foster richer mathematical understanding.

The teacher created a classroom climate that nurtured confidence in his Pāsifika students to participate successfully in mathematical discourse. He shifted his students' passive learning behaviours by scaffolding an array of skills so that they could rely on one another interdependently during the learning process. As a result, a caring and supportive culture in which students felt safe to explain their ideas and take risks in their learning was gradually developed.

This finding reflects the findings in research studies (e.g., Gay, 2010; Goos, 2004; Noddings, 2008) that a culturally safe learning environment is critical to the success of mathematical discourse. As in Escalante and Dirmann's study (1990), the researchers and the students worked together in a climate where mutual support, individual and collective accountability were always present in the class.

5.5 ENHANCING MATHEMATICAL DISCOURSE

The ethos of family that governed mutual support, individual and collective accountability within the learning community was important to maintain productive mathematical discourse. The teacher in this current study found it necessary to enforce the group collaboration rules regularly to ensure every student had equal access to the discussion. This particular enforcement of social norms was consistent in research studies (e.g., Chapin et al., 2013; McChesney, 2009; Walshaw & Anthony, 2008; Yackel & Cobb, 1996). The teacher in the current study understood that simply putting students in groups to work together would not guarantee productive discourse. As a consequence, the teacher needed to closely monitor group interaction so that the students in each group would mutually support each other in tackling a common task. Ultimately, for group work to be successful, teachers need to continually remind students that helping each other is the most essential part of the learning process in the classroom, resonating with the ethos of a caring culture demonstrated in the study of Noddings (2008).

In the current study, there were times when the students contravened the notion of group responsibility and resisted participating in the discussions. This finding was similar to Yackel's study (1995) that even though explanations are offered by students in a group, others may not feel compelled to personally digest the ideas presented to them. In the current study, the teacher intervened in the group discussion when a lack of collaboration was observed and emphasised the unfairness of relying on one student to do all the work. Subsequently, he reiterated the idea of collective accountability: "*the idea of working in the group*

is to bring all of you together so that you all have a common understanding - lesson six". In doing this action the teacher was demonstrating what Noddings (2008) terms as interpersonal reasoning. Noddings explains that teachers need to have a strong grasp of interpersonal reasoning in order to maintain the caring relationship between students during the engagement in dialogue.

To enhance the mathematical discourse between students, the teacher in the current study worked towards building his students' ability to prove their ideas, as well as to critique the ideas of others in the class. He believed that engaging in mathematical arguments in the classroom deepened rich understanding of concepts and enabled the students to make connections to different mathematical ideas. He provided students many opportunities to engage in making mathematical explanations and justifications. These findings are consistent with many other researchers (e.g., Hunter, 2010; Lamberg, 2013; Kazemi & Stipek, 2001; Yackel & Cobb, 1996) who illustrated that it takes time for students to develop these socio-mathematical norms. Students were able to evaluate and find the differences in each other's mathematical work and this gave them autonomy to validate or refute a range of possible solution strategies.

By the end of the study, as the social and socio-mathematical norms became established, students had developed more refined social and intellectual autonomy in mathematics. The teacher spent less time stating and modelling expectations. His earlier explicit actions in supporting students to engage in discourse led to many of the less confident students demonstrating higher level mathematical behaviour. This finding reflected similar results in many studies (e.g., McCrone, 2005; White, 2003; Yackel & Cobb, 1996). For example, students in this study began to insist that other group members must justify their reasoning using concrete materials: *"Are you sure you need to show us how you got that. The bit about needing twenty-five coloured cubes to cover this wooden block."* Similarly, a previous silent or reticent student was seen at the end of the study actively pressing a group in a whole class sharing session to justify their thinking: *"How do you know the remainder is forty per cent?"*

The teacher in the current study used questioning to stimulate student engagement in mathematical discourse. This finding was consistent in studies where questioning is an effective sense-making tool (e.g., Chapin et al., 2013; Franke et al., 2015; Goos; 2004; Kazemi & Hintz, 2014). He modelled explicitly how to ask questions, and pressed students to ask focused questions in a respectful way that was acceptable in their culture. Instead of using funnelling questions (Franke et al., 2009) to move students in the direction the teacher thought was most effective, he used more focused questions that encouraged students to do most of the mathematical work. He did this by focusing attention on particular aspects of the students' explanations without guiding students in specific or predetermined directions. This is similar to the teacher questioning described by Franke and her colleagues (2009) in their study.

Questioning was also used by the teacher as a powerful tool for initiating and providing a focus for classroom discussion. More importantly, the use of questioning enhanced group discussion. The teacher in the study did not use the traditional initiate-response-evaluative (IRE) pattern of questioning, where teacher asks a question and looks for correct answers from the students. The teacher's decision is justified in the light that the IRE pattern of questioning is considered a cultural mismatch in some studies (e.g., Gay, 2010; MacFarlane, 2004), because it controls and inhibits students' participation due to undermining their home experiences. Contrary to the IRE pattern, the teacher in this study used questions to initiate class discussions and linked students' responses to the nature and context of the task. His use of questioning to ask students to connect or build on other students' responses was consistent with many studies (e.g., Brodie, 2007; Khisty & Chval; 2002; McChesney, 2009).

The teacher in the current study enforced the norm of asking questions after a conjecture or statement was made by others. Having in place a procedure that slowed down students' reactions to one another's statements provided a way of maintaining civility among students as in Rittenhouse's study (1998). Similarly, using a hand gesture of agreement or disagreement indicated that the teacher wanted the class to think about their decisions carefully. This finding mirrors the teacher's action in Rittenhouse's research (1998). Ultimately, the teacher

demonstrates his desire to know who said what and hold the particular student accountable for their claims. The hand gestures caused students to think twice about what they said and how they said it. They also helped to preserve a speaker's self-esteem when confronted about his or her ideas and fostered a sense of responsibility on the part of those wishing to disagree or ask more questions if they felt a degree of uncertainty.

As the study progressed, the teacher increasingly used questioning to press for students' understanding of the deeper mathematical ideas embedded in the task or in other students' responses. The teacher used various types of questions to enhance mathematical discourse. His use of supporting moves such as probing, scaffolding, and positioning were similar to the teacher actions in the work by Frank et al., (2015). For example, he probed students to justify their thinking: "*how do you know that two-eighths of one hundred and twenty equals thirty?*" (Lesson six). At times, he would provide a scaffold using previous examples to extend thinking, "*Looking at the square from the last example and compare to this square, what does the square tell you? What information do you know about the square?*" (Lesson nine). Often, he used questioning as a positioning move to press students to explain in more detailed way, "*she is not convinced so you need to revoice or show a different way.*" (Lesson thirteen). Evidently, the teacher in the current study increased students' mathematical autonomy in expressing their thinking through consistently pressing students to justify their reasoning. Kazemi and Stipek (2001) explained that students' mathematical learning was enhanced when teachers exhibited high-press behaviours that compelled students to provide reasoning for their mathematical decisions and focused on conceptual rather than procedural knowledge.

In the current study, the teacher consistently reinforced group collaboration as a collective endeavour in order to improve students' ability to talk mathematically. He also needed to constantly monitor students' engagement in discussion and think of ways to advance students' mathematical thinking. This finding resonated with the study by Sullivan et al. (2013) that the teacher maintained

high levels of student engagement in the sense making process through his on-going interactive and intellectual input. In doing so, students in the current study collectively recognised the importance of making mathematical sense of the contributions offered by others. As a result, social norms eventually became socio-mathematical norms when students developed what counted as taken-as-shared mathematical explanations or justifications.

5.5.1 Using explicit language and cultural resources in mathematical discourse

Explicit mathematical language played an important role in advancing students' understanding of mathematics, which in turn enhanced their mathematical talk. Similar to other research studies (e.g., Khisty & Chval, 2002; McChesney, 2009; Moschkovich, 2010), the teacher in the current study played a critical role in shaping the development of novice mathematicians to use explicit mathematical language. A range of approaches was used by the teacher to facilitate the students to use more concise and specific mathematical terms to enhance understanding. As the discussion unfolded, the teacher in the current study emphasised important content by repeating a student contribution such as a key term or phrase. Repetition of key mathematical ideas is a useful way to endorse an important contribution made by a student (McChesney, 2009). According to Lykins (2015) another advantage of using repetition is it helps students to remember new information. In the current study, the teacher repeated key mathematical ideas in various ways to enhance students' understanding so that they could explain these ideas more confidently in classroom discussion.

Research studies (e.g., Khisty & Chval, 2002; Johnson, 2010) show that using explicit language in discourse fosters deeper mathematical understanding. The findings in the current study showed that the teacher encouraged students to use explicit language and specific mathematical terms whenever appropriate in classroom discussion while integrating students' diverse cultural tools. At the concluding session, the teacher connected students' learning to key mathematical ideas by noting important ideas developed in the lesson. As Schleppegrel (2010) contends, cultural tools are invaluable learning resources

in the mathematics classroom because they offer a different perspective in constructing mathematics knowledge. In the current study, the teacher encouraged his students to use their own preferred learning style in the classroom such as drawings, gestures, and words from their native language to express their thinking to extend learning.

Teachers contribute important learning resources to the knowledge pool between the members of a mathematical discussion. Research studies (e.g., Khisty & Chval, 2002; McChesney, 2009;) found that it was necessary for teachers to introduce the appropriate mathematical language in classroom discussion. The findings in this study showed that the teacher named the significant terms in the mathematical discourse, which Kibel (1992) refers to as verbal labelling. For example, the teacher scaffolded learning by providing the language while students manipulated materials to compare and contrast the difference of face area of two different sized cubes. The teacher verbally labelled the significant aspects of area and highlighted the importance of the meaning of square units in terms of measuring face area. Hence, he connected the mathematical language of concrete experiences to the development of abstract concepts. Moving students from the concrete to the abstract with the manipulation of material is a practical strategy to bridge mathematical understanding and broaden discourse, which has been documented in previous studies (e.g., Civil, 2014; Kazemi & Hintz, 2014; Rittenhouse, 1998; Roth & Radford, 2010).

In addition, he also encouraged students to rely on their cultural resources and work together to solve mathematical problems. The teacher in the current study used an amalgamation of students' ideas from both the formal instruction in the classroom and cultural knowledge as a catalyst for extending mathematical discourse. Similar to the teacher actions in the study by Makar et al. (2015), it was important to accept tentative or partially formed ideas from students' contributions to extend the mathematical understanding shared by all members in the discussion. The teacher's analytical scaffolding reflected the *whakatauaki*, the Maori's value of supporting each other in learning with a student holding one

handle of the basket and the teacher holding the other handle in the unfolding of mathematical conversation. According to (McChesney, 2009), the basket is a reservoir of knowledge in the form of mathematical resources provided by both the teacher's and the students' discourse that can promote further learning. As the shared basket of knowledge becomes more profound, more mathematical insights would be discovered, which results in richer mathematical discourse.

In the current study, the teacher's explicit use of mathematical language and encouragement of students to convincingly craft mathematical arguments to explain and justify their ideas was similar to the classroom activities described by Khisty and Chval (2002). He frequently used mathematical words in his talk and capitalised on students' cultural knowledge to make links between mathematical language, students' former understandings, and home languages. In the current study, the teacher built on the students' cultural experiences and language by asking them to construct meaning for the definition of area by connecting the area idea to the Cook Island patterned blanket, *tivaevae*. The teacher used his talk approach not only to extend students' mathematical explanations, but also connect them to the meaning of specialised mathematical terms (e.g. perimeter, unit square), ultimately broadening all the students' cognitive ability to appreciate overarching mathematical ideas. It is evident that by the end of the study, students had become competent in using the specific mathematical terms in justifying their solution strategy.

5.6 SUMMARY

The teacher in this study drew on Pāsifika cultural values of respect, family, reciprocity, and belonging as a powerful learning model to create a supportive, caring, and effective learning environment. These values were also used to support students in making friendly arguments and taking ownership of their learning through classroom discussion. The teacher used his knowledge of his students' capabilities, learning methodology, and cultural resources such as home language and experiences to transform mathematics into an accessible context. He often shaped classroom discussions by directing the mathematical focus, eliminating distractions, and highlighting important mathematical ideas. It is evident that the teacher consistently supported students' mathematical learning by facilitating the development of productive discourse. He used talk moves such as turn-and-talk, repeating, revoicing, and wait time to develop social norms and socio-mathematical norms to support mathematical discourse. The social norms of explanation and justification became taken-as-shared socio-mathematical norms through the ongoing interactive and intellectual input from the teacher so that students could freely articulate conventional mathematical ideas in their discussions. Finally, it was through active participation and constant group collaboration in building the shared reservoir of knowledge both from the teacher and students that the students became more proficient in using explicit mathematical terms and symbolic representations in mathematical discourse.

CHAPTER SIX – CONCLUSION

6.1 INTRODUCTION

The intention of this thesis was to examine how teachers' actions support Pāsifika students to engage in mathematical discourse through culturally responsive practices. An underlying aim of this study was to explore how a culturally responsive pedagogy in mathematics classrooms can potentially foster Pāsifika students' engagement and participation in mathematical discourse. A further focus was to analyse how the teacher drew on cultural values and practices to develop social and socio-mathematical norms that supported students' discourse in learning mathematics. Detailed descriptions of the findings have been presented as well as a discussion of the teacher's actions in drawing on the Pāsifika values and cultural practices as valuable learning resources. The synthesis of the ideas presented in these findings illustrates the complex nature of the teaching and learning process, the importance of drawing on students' cultural contexts, constructing a safe learning environment, and using explicit language.

Finally, the conclusions of the study outline the implications for current classroom practice and suggestions for further research.

6.2 THE COMPLEX NATURE OF TEACHING AND THE LEARNING PROCESS

This investigation took place within a real classroom of students with Pāsifika ethnicity. It was evident that the role of the teacher is multifaceted when incorporating Pāsifika values to shape participation and communication patterns in a culturally safe mathematics classroom. In this study, the teacher played different roles according to the needs of the classroom, which included a cultural facilitator, task designer, monitor of productive discourse, and developer of mathematical learning.

Although there are common Pāsifika concepts of reciprocity, collectivism, and community that teachers could draw on to foster a culturally responsive classroom, consideration must be given to the differences in cultural practices between Pāsifika cultures and students' learning styles and beliefs. Classrooms are complex in nature because they consist of multiple variables which could impact on teaching and learning. This is because teaching is a dynamic process where the teacher is required to take all their students' cultural strengths and weaknesses into consideration while implementing appropriate instructional tasks to meet the curriculum demands.

6.3 DRAWING ON CULTURAL CONTEXTS AND HOME LANGUAGE

In this study, particular tasks designed by the teacher that drew on cultural contexts and home language acted as key tools which impacted on students' learning of mathematics. Students were pleased to see their culture reflected in the mathematical tasks, which promoted student engagement in classroom discussion. The teacher ensured that these tasks were challenging and open-ended to reflect Pāsifika culture such as *tona'i* (*Sunday lunch*), *tivaevae* (*patterned quilt*) and *ta'ovala* (*mat skirt*). It was necessary to affirm the students' cultures by encouraging them to talk about the task in their home language and to use materials or inscription to make sense of the key mathematical ideas in the task. As Schleppegrel(2010) contends, cultural tools are invaluable learning resources in the mathematics classroom because they offer a different perspective in constructing mathematics knowledge. Whenever possible, students should be positioned as cultural experts to explain the meaning of cultural practices. Teachers need to embrace the value of *ako* (reciprocity) because students' different cultural perspectives broaden and enrich mathematical discourse (Civil, 2014). Furthermore, giving students the right to talk about mathematics in their own culture empowers students to be successful learners of mathematics. Most significantly, drawing on students' cultural practices and languages serves to bridge their intuitive understanding with conventional mathematical understanding.

6.4 CONSTRUCTING A CULTURALLY SAFE LEARNING ENVIRONMENT

The study highlighted the importance of a safe and supportive learning environment, one which truly promotes an ethos of caring (Noddings, 2008). The findings of the study showed that the teacher drew on the Pāsifika values of family, collectivism, and communalism to establish a safe learning environment. He emphasised the students' personal and collective accountability to ensure equitable participation of the students in classroom discussion. The success of learning mathematics was dependent on the students' caring demeanour to mutually support each other.

During a lesson, the teacher monitored and supported the interactions of students in small groups and in larger group presentations. He employed interpersonal reasoning by encouraging shy and less confident students to take incremental steps to participate in collaborative discourse and publicly acknowledged their contribution to the group's learning. To further encourage the students' engagement, he infused interesting questions to motivate them to reflect on the thinking of others, eventually arriving at a solution by themselves. He would intervene in a discussion when some students contravened the group responsibility of supporting each other in the sense-making process. As the study progressed, through the teacher's consistent scaffolding and reminders of the expected norms, students became more confident in asking valid questions to make themselves understand the strategies others put forward in the group sharing sessions.

6.5 USING EXPLICIT MATHEMATICAL LANGUAGE

Findings from this study support the recommendations from culturally responsive studies (e.g., Gay, 2010; Johnson, 2010; Khisty & Chval; 2002) that Pāsifika students who are additional language learners require multiple opportunities to engage in mathematical discussions. Ultimately, teachers are required to encourage the use of appropriate mathematical terms and symbols incorporating cultural resources to enrich students' conceptual understanding of important mathematical ideas.

The importance of time and space in supporting students learning mathematics is evident. The teacher provided the time and space for students to listen and make sense of the problem before discussion. Partial understanding and misconceptions could be identified and extensively explored in small group discussion. As a result, errors became invaluable learning opportunities within the class so that students could figure out complex ideas and develop deeper conceptual understanding. Extended time and space was offered to students to practise gaining proficiency in finding and explaining solution strategies. In addition, students were also able to explore and use different questions and prompts to make sense of other's strategies, providing an opportunity to rehearse their reasoned explanations. During their discussion, they were encouraged to use multiple resources such as gestures, materials, their home language, and practices to connect concrete ideas to abstract counterparts. The guided discussion culminated in providing students with opportunities to learn, to practise, and to apply specific mathematical language to enhance conceptual understanding.

At the end of the study, discourse gradually became more collaborative. Through the enactment of socio-mathematical norms, explanations were mathematical in nature. The need for students to make clear explanations and negotiate mathematical differences had become taken-as-shared expectations. Students initiated discussions in small groups and built on each other's ideas during on-going interactions and through active participation, rather than requiring the teacher's affirmation. As a result, all the students valued each other's contributions and were able to justify the chosen solution strategies.

6.6 TEACHING IMPLICATIONS

The implications for teaching Pāsifika students in multi-cultural classrooms are as follows:

1. Teachers should design or select tasks which reflect the cultural contexts of students to foster engagement.

2. Invite students to use home language or their preferred language in discussion to enhance their understanding of a mathematical task.
3. Construct a caring culture to support each other in learning mathematics.
4. Highlight mistakes as valuable learning opportunities.
5. Enforce personal and collective accountability for a successful discussion to ensure equitable participation from all students.
6. Encourage students to use cultural resources such as code-switching, translanguaging, using pictures or drawings, and gestures to broaden mathematical discourse.
7. Provide language models to ask questions, explain, justify, and critique others' ideas.
8. Present multiple opportunities to practise explicit language in mathematical arguments.

6.7 OPPORTUNITIES FOR FURTHER RESEARCH

Due to the small sample size and the difference in teaching pedagogy of the teacher, the results of this study can only indicate emerging perceptions into how teachers draw on Pāsifika cultural values and practices to support students in mathematical discourse.

It would be timely to examine and compare the perspectives and roles of younger or older students where teachers employ a similar culturally responsive pedagogy to support their mathematical discourse. Further research would be beneficial to explore how teachers develop various culturally responsive practices such as translanguaging to scaffold students into making sense of mathematics. Potential research studies may find it worthwhile exploring the diverse ways students use language and cultural resources to enhance mathematical discourse in different decile schools. Whilst the establishment of social and socio-mathematical norms are documented within studies of discourse and inquiry classrooms (e.g., Hunter, 2007), in general, studies which focus on drawing upon Pāsifika values or practices in relation to engagement in

mathematical discourse are relatively limited. More research into culturally responsive teaching in different mathematics classroom settings is needed.

6.8 CONCLUDING THOUGHTS

The evidence from this research would indicate that incorporating students' language and cultural values to develop social and socio-mathematical norms in a classroom makes a significant difference to Pāsifika students' learning of mathematics. As a result, students' cultural heritage and practices are affirmed and treated as invaluable learning resources for mathematics learning.

When Pāsifika students see their culture reflected in the mathematics learning, they feel comfortable to make connections between their home experiences and challenges faced at school. Hence, even the weaker students are more likely to articulate their ideas and participate in the classroom discussion. Through active participation in mathematics activities, by working collaboratively and being obligated to ask valid questions, explain, and justify, students became better sense-makers within their own culture and developed a deeper conceptual understanding of mathematics.

REFERENCES

- Allen, K. (2012). Keys to successful group work: Culture, structure, nurture. *The Mathematics Teacher*, 106(4), 305-312.
- Alton-Lee, A., Hunter, R., Sinnema, C., & Pulegatoa-Diggi, C. (2010). *Case 1 Developing communities of mathematical inquiry. Quality teaching for diverse (all) learners in schooling. 2nd iteration best evidence synthesis in progress*. Retrieved from <http://www.educationcounts.govt.nz/goto/BES>
- Anae, M., Coxon, E., Mara, D., Wendt-Samu, T., & Finau, C. (2001). *Pasifika education guidelines: Final report*. Wellington: Auckland Uniservices.
- Anthony, G., & Hunter, R. (2005). A window into mathematics classrooms: Traditional to reform. *New Zealand Journal of Educational Studies*, 40(1), 25-43.
- Anthony, G., & Walshaw, M. (2009). *Effective pedagogy in mathematics: Educational practices series*. Geneva: UNESCO.
- Au, K. H. (1993). *Literacy instruction in multicultural settings*. New York, NY: Harcourt Brace.
- Averill, R., Anderson, D., Easton, H., Maro, P., Smith, D., & Hynds, A. (2009). Culturally responsive teaching of mathematics: Three models from linked studies. *Journal for Research in Mathematics Education*, 40(2), 157-186.
- Bell, C. V., & Pape, S. J. (2012). Scaffolding students' opportunities to learn mathematics through social interactions. *Mathematics Education Research Journal*, 24(4), 423-445.
- Berg, B., & Lune, H. (2012). *Qualitative research methods for the social sciences* (8th ed.). New Jersey: Pearson.
- Bills, T., & Hunter, R. (2015). The role of cultural capital in creating equity for Pasifika learners in mathematics. In V. B. Marshman, (Ed.), *Mathematics education in the margins. (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia)* (pp. 109-116). Sunshine Coast: MERGA.
- Boaler, J. & Brodie, K. (2004). The importance, nature and impact of teacher questions. In D. McDougall & J. Ross (Eds.), *Proceedings of the 26th meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 773-782). Toronto: Canada.

- Brevik, L. M., Fosse, B. O., & Rødnes, K. A. (2014). Language, learning, and teacher professionalism: An investigation of specialized language use among pupils, teachers, and student teachers. *International Journal of Educational Research*, 68, 46-56.
- Brodie, K. (2007). Teaching with conversations: Beginnings and endings. *For the Learning of Mathematics*, 27(1), 17-23.
- Bruner, J. (1990). *Acts of meaning*. Cambridge, MA: Harvard University Press.
- Bruner, J. (1996). *The culture of education*. Cambridge, MA: Harvard University Press.
- Burton, N., Brundrett, M., & Jones, M. (2014). *Doing your education research project*. London, England: SAGE Publications INC.
- Chapin, S., O'Connor, C., & Anderson, N. (2009). *Classroom discussions: Using math talk to help students learn*. California, CA: Math Solutions.
- Chapin, S., O'Connor, C., & Anderson, N. (2013). *Classroom discussions in math: A teacher's guide for using talking moves to support the Common Core and more, Grade K-6* (3rd ed.). California, CA: Math Solutions.
- Civil, M. (2014). Guest editorial: Musings around participation in the mathematics classroom. *The Mathematics Educator*, 23(2), 3-22.
- Civil, M., & Planas, N. (2004). Participating in the mathematics classroom: Does every student have a voice? *For the Learning of Mathematics*, 24(1), 7-12.
- Cobb, P. (2006). Research in Mathematics Education: What can it teach us about human learning? In K. Sawyer (Ed.), *Cambridge Handbook of the learning sciences* (pp. 545-564). New York, NY: Cambridge University Press.
- Cobb, P., Stephan, M., McClain, K., & Gravemeijer, K. (2011). Participating in classroom mathematical practices. In A. Y. Sfard, E. K. Gravemeijer & P. Cobb (Eds.), *A journey in mathematics education research* (pp. 117-163). New York: Springer.
- Common Core State Standards. (2012). Common Core State Standards for Mathematics. Retrieved from http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf
- Escalante, J. & Dirmann, J. (1990). The Jamie Escalante math program. *Journal of Negro Education*, 59(30), 407-423.

- Esmonde, I. (2009). Ideas and identities: Supporting equity in cooperative mathematics learning. *Review of Educational Research*, 79(2), 1008-1043.
- Fletcher, J., Parkhill, F. & Fa'afoi, A (2005). What factors promote and support Pasifika students in reading and writing? . *Set: Research Information for Teachers*, 2, 2-8.
- Forman, E. (1996). Learning mathematics as participation in classroom practice: Implications of sociocultural theory for education reform. In L. Steffe & P. Neshier (Eds.), *Theories of mathematical learning* (pp. 115-129). Mahwah, N J: Lawrence Erlbaum Associates Publishers.
- Franke, M., Turrou, A., Webb, N., Ing, M., Wong, J., Shin, N., & Fernandez, C. (2015). Student Engagement with Others' Mathematical Ideas: The Role of Teacher Invitation and Support Moves. *The Elementary School Journal*, 116(126-148).
- Franke, M., Webb, N., Chan, A., Ing, M., Freund, D., & Battey, D. (2009). Teacher questioning to elicit students' mathematical thinking in elementary school classrooms. *Journal of Teacher Education*, 60(4), 380-392.
- Garcia, O, & Wei, L. (2014). *Translanguaging: Language, bilingualism and education*. New York: Palgrave MacMillan.
- Gay, G. (2010). *Culturally responsive teaching: Theory, research, and practice*. New York, NY: Teachers college Press, Columbia University.
- Gee, J. P., & Clinton, K. (2000). An African American child's science talk: Co-construction of meaning from the perspectives of multiple discourses. In M. H. Gallego (Ed.), *What counts as literacy: Challenging the school standard* (pp. 118-138). New York: Teachers College Press.
- Goos, M. (2004). Learning mathematics in a classroom community of inquiry. *Journal for Research in Mathematics Education*, 35(4), 258-291.
- Goos, M. (2014). Communities of practice in mathematics teacher education. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 82-84). Dordrecht: Springer Reference.
- Goos, M., Galbraith, P., & Renshaw, P. (2004). Establishing a community of practice in a secondary mathematics classroom. In B. Allen & S. Johnstone-Wilder (Eds.), *Mathematics education: Exploring the culture of learning*. London: Falmer Press.
- Hunter, R. (2007). *Teachers developing communities of mathematical inquiry*. Auckland, New Zealand: Massey University.

- Hunter, R. (2010). Coming to know mathematics through “acting, talking and doing” mathematics. In L. Sparrow, B. Kissane & C. Hurst (Eds.), *Shaping the future of mathematics education (Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia)* (Vol. 1, pp. 264-271). Freemantle, Australia: MERGA.
- Hunter, R., & Anthony, G. (2011). Forging mathematical relationships in inquiry-based classrooms with Pasifika students. *Journal of Urban Mathematics Education, 4*(1), 98-119.
- Jackson, K., Shanhan, E., Gibbons, L., & Cobb, P. (2012). Launching complex tasks. *Mathematics Teaching in the Middle School, 18*(1), 24-29.
- Johnson, A. (2010). *Teaching mathematics to culturally and linguistically diverse learners*. Boston: Pearson.
- Kazemi, E., & Stipek, D. (2001). Promoting conceptual thinking in four upper-elementary mathematics classrooms. *The Elementary School Journal, 102*(1), 59-80.
- Kazemi, E., & Hintz, A. (2014). *Intentional Talk*. Portland, Maine: Stenhouse Publishers.
- Khisty, L. I., & Chval, K. B. (2002). Pedagogic discourse and equity in mathematics: When teachers’ talk matters. *Mathematics Education Research Journal, 14*(3), 154-168.
- Kibel, M. (1992). Linking language to action. In T. R. Miles & E. Miles (Eds.), *Dyslexia and Mathematics*. London: Routledge.
- Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of African American children*. San Francisco: Jossey-Bass.
- Lamberg, T. (2013). *Whole class mathematics discussion: Improving in-depth mathematical thinking and learning*. New Jersey: Pearson.
- Lampert, M. (1998). Investigating teaching practice. In M. Lampert & M. L. Blunk (Eds.), *Talking mathematics in school*. New York, NY: Cambridge University Press.
- Latu, V. (2005). Language factors that affect mathematics teaching and learning of Pasifika students. In P. Clarkson, A. Clarkson, D. Gronn, M. Horne & M. McDonough, A (Eds.), *Building connections: Research, theory and practice (Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia)* (Vol. 2, pp. 483-490). Sydney: MERGA.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge.

- Lichtman, M. (2013). *Qualitative research in education*. Los Angeles SAGE Publications.
- Lipka, J., Yanez, E., Andrew-Ihrke, D., & Adam, S. (2009). A two-way process for developing effective culturally based math: Examples from Math in a Cultural Context. In B. M. Greer, S. Mukhopadhyay, A. Powell & S. Nelson-Barber (Eds.), *Culturally responsive mathematics education* (pp. 257-280). New York, NY: Routledge.
- Lykins, A. (2015). Using repetitions to make ideas stick. *The Mathematics Teacher*, 108(8), 622-625.
- MacFarlane, A. (2004). *Kia hiwa ra! Listen to culture*. Wellington, New Zealand: New Zealand Council for Educational Research
- Makar, K., Bakker, A., & Ben-Zvi, D. (2015). Scaffolding norms of argumentation-based inquiry in a primary mathematics classroom. doi:10.1007/s11858-015-0732-1
- Manoucheri, A., & St John, S. (2006). From classroom discussion to group discourse. *Mathematics Teacher*, 99(8), 544-552.
- Massey University. (2000). *Code of ethical conduct for teaching and research involving human subjects*. Palmerston North: Massey University.
- McCrone, S. (2005). The development of mathematical discussions: An investigation in a fifth grade classroom. *Mathematical Thinking and Learning*, 7(2), 111-133.
- McChesney, J. (2009). I worked out a wicked way to do it: Students, teachers and classroom talk. In R. H. Averill, R (Ed.), *Teaching secondary school mathematics and statistics: Evidence-based practice*. Wellington, New Zealand: NZCER Press.
- Mercer, N. (2000). *Words & minds*. London: Routledge.
- Mercer, N. (2002). Developing dialogues. In G. Wells & G. Claxton (Eds.), *Learning for life in the 21st century* (pp. 141-153). Oxford, UK: Blackwell Publishers.
- Mercer, N., & Littleton, K. (2007). *Dialogue and the development of children's thinking*. Oxon, England: Routledge.
- Merriam, S. (1998). *Qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass Publishers.
- Merriam, S. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

- Ministry of Education. (2007). *The New Zealand Curriculum*. Wellington, New Zealand: Learning Media.
- Ministry of Education. (2009). *The New Zealand Curriculum: Mathematics standards for years 1-8*. Wellington, New Zealand: Learning Media.
- Ministry of Education. (2013). *Pasifika Education Plan*. Wellington, New Zealand: Ministry of Education.
- Ministry of Education. (2014). National Standards Achievement Results. Retrieved from https://www.educationcounts.govt.nz/_data/assets/pdf_file/0009/148851/National-Standards-Achievements-Results-2014.pdf
- Moschkovich, J. (1999). Supporting the participation of English language learners in mathematical discussion. *For the Learning of Mathematics*, 19(1), 11-19.
- Moschkovich, J. (2010). Recommendation for research on language and mathematics education. In J. Moschkovich (Ed.), *Language and mathematics education*. Charlotte, NC: Information Age Publishing, INC.
- Moschkovich, J. (2012). How equity concerns lead to attention to mathematical discourse. In B. Herbel-Eisenmann, J. Choppin, D. Wagner & D. Pimm (Eds.), *Equity in discourse for mathematics education: Theories, practices, and policies* (pp. 89-105). London, United Kingdom: Springer.
- Newby, P. (2014). *Research methods for education*. Oxon, England: Routledge.
- Noddings, N. (2008). Caring and moral education. In L. N. Nucci (Ed.), *Handbook of moral and character education* (pp. 161-174). New York, NY: Routledge.
- Pimm, D. (1987). *Speaking mathematically: Communication in mathematics classrooms*. London, England: Routledge & Kegan Paul.
- Rittenhouse, P. S. (1998). The teacher's role in mathematical conversation: Stepping in and stepping out. In M. Lampert & M. L. Blunk (Eds.), *Talking mathematics in school* (pp. 163-189). Cambridge: University Press.
- Roth, W., & Radford, L. (2010). Re/thinking the zone of proximal development (symmetrically). *Mind, Culture, and Activity*, 17(4), 299–307.
- Schleppegrell, M. (2010). Language in mathematics teaching and learning. In J. Moschkovich (Ed.), *Language and mathematics education: Multiple perspectives and directions for research* (pp. 73-112). Charlotte, NC: Information Age Publishing, INC.

- Selling, S. (2014). Making mathematical practices explicit in discourse: Experienced and beginning instruction. Retrieved from <https://s3.amazonaws.com/conference-handouts/2015-nctm-boston-research/pdfs>
- Sfard, A. & Cobb, P. (2006). Research in Mathematics Education: What can it teach us about human learning? In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 545-564). New York, NY: Cambridge University Press.
- Sherin, M., Linsenmeiser, K., & Van Es, E. (2009). Selecting video clips to promote mathematics teachers' discussion of student thinking. *Journal of Teacher Education*, 60(3), 213-230.
- Spiller, L. (2012). "How can we teach them when they won't listen?" How teacher beliefs about Pasifika values and Pasifika ways of learning affect student behaviour and achievement. *Set*, 58-66.
- Sullivan, P., Mousley, J., & Jorgensen, R. (2009). Tasks and pedagogies that facilitate mathematical problem solving. In B. Kaur, B. Yeap & M. Kapur (Eds.), *Mathematical problem solving Yearbook 2009* (pp. 17-42).
- Sullivan, P, Clarke, P, Clarke, D, & Roche, A. (2013). Teachers' decisions about mathematics tasks when planning. In V. Steinle & L. B. Ball, C (Eds.), *Mathematics education: Yesterday, today and tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia)*. Melbourne, VIC: MERGA.
- Tuafuti, P. (2010). Additive bilingual education: Unlocking the culture silence. MAI. Retrieved from <http://review.mai.ac.nz>
- Walshaw, M. & Anthony, G. (2007). *Classroom arrangements that benefit students*. Retrieved from <http://www.merga.net.au/documents/RP612006.pdf>
- Walshaw, M. & Anthony, G. (2008). The teacher's role in classroom discourse: A review of recent research into mathematics classrooms. *Review of Educational Research*, 78(3), 516-551.
- Wegerif, R., & Dawes, L. (2004). *Thinking and learning with ICT: Raising achievement in primary classrooms*. London: Routledge.
- Wells, G. (1999). *Dialogic inquiry. Toward a sociocultural practice and theory of education*. Cambridge: Cambridge University Press.
- White, D. (2003). Promoting productive mathematical classroom discourse. *Journal of Mathematical Behaviour*, 22, 37-53.

- Winsor, M. (2007-2008). Bridging the language barrier in mathematics. *The Mathematics Teacher*, 101(5), 372-378.
- Wood, T. (2002). What does it mean to teach mathematics differently? In B. Barton, K. Irwin, M. Pfannkuch & M. Thomas (Eds.), *Proceedings of the 25th annual conference of the Mathematics Education Research Group of Australasia: Mathematics Education in the South Pacific* (pp. 350-357). Sydney, Australia: Mathematics Education Research Group of Australasia.
- Yackel, E. (1995). Children's talk in inquiry mathematics classrooms. In P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meaning*. Hillsdale, NJ: Lawrence Erlbaum.
- Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education*, 27(4), 458-477.
- Yackel, E. (2002). What we can learn from analyzing the teacher's role in collective argumentation. *Journal of Mathematical Behaviour*, 21, 423-440.
- Yin, R. (2012). *Applications of case study research*. Thousand Oaks, CA: SAGE.

APPENDIX A – INTERVIEW QUESTIONS

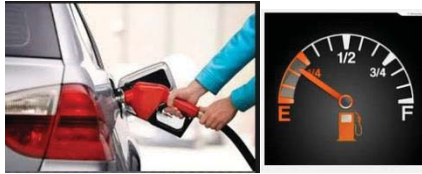
Part one: Student questions

- When your teacher is getting you to work together how does he use your culture or things that you do at home to support you?
- Is it important to be able to explain your thinking to other people in maths? Why?
- How does your teacher support you to question other people and disagree?
- How does your teacher help you to understand the problems and tasks?
- How does it make you feel to see your culture reflected in the maths problems and tasks?
- Does it help you in your maths to have your culture reflected in the problems and tasks? How?

Part two: Teacher questions

1. How do you draw on the students' culture and home life to support them to work together in the maths classroom?
2. How do you draw on the students' culture and home life to support them to engage questioning, agreeing and disagreeing, and mathematical argumentation?
3. What factors do you think about when you write and develop maths problems?
4. How do you ensure that the students can engage in the mathematical problem/task?
5. How do you support students to explain their mathematical thinking?

APPENDIX B –MATHEMATICAL PROBLEM TASKS



1. Filling up the car

a. Mr Downes need to fill his car with petrol.

His car takes 60 litres of 91 Octane petrol at \$1.67 per litre.

How much did it cost to fill his car?

b. Every 4th fill he needs to use 96 Octane petrol to help the performance of the motor, so,

he fuelled up with 96 Octane petrol at \$1.79 per litre.

c. His car took 58.5 litres of 96 Octane at \$1.79 per litre.

How much did it cost to fill his car?

f. If he had a 10 cent per litre discount voucher,

How much would save him?



2. Sunday Feeds

a. Mele and Lina each had 120grams of corned beef to use for their tona'i on Sunday. Mele used $\frac{2}{8}$ of her corned beef and Lina used $\frac{5}{8}$ of hers. How much grams of corned beef did they each use? Who used more?

b. This time Mele and Lina both went and bought the 425 grams tinned corned beef to use for their tona'i on Sunday with some visiting cousins from overseas.

Mele used four fifths of her corned beef tin and Tina used two fifths of hers.

How much grams of corned beef did they each use?

c. This was the last time Mele and Lina had to host a group of people for tona'i so they decided to each make their own unique special dish for Sunday. Mele brought a 6KG tinned corned beef for both of them to use for their

special dish at church for the church people. Mele used $\frac{3}{10}$ of their corned beef for her corned beef and spaghetti dish and Lina used the rest for her “corned beef and cabbage” dish. How much did each use in grams.

3. Malakai’s mother is making ta’ovala for all the boys in the Tongan group at school. Each needs $1\frac{1}{2}$ metres of mat and she has 30 metres.



How many ta’ovala does she make?

Malakai’s mother is making ta’ovala for all the boys in the Tongan group at school. Each boy needs $1\frac{3}{4}$ metres of mat and she has $50\frac{1}{2}$ metres. How many ta’ovala does she make?

Malakai’s mother is making ta’ovala for all the big boys in the Tongan group at school. Each boy needs 1 and $\frac{3}{5}$ metres of mat and she has $75\frac{7}{8}$ metres. How many ta’ovala does she make?

Malakai’s mother is making ta’ovala for all the big boys in the Tongan group at school. Each boy needs 2 and $\frac{7}{9}$ metres of mat and she has $123\frac{3}{4}$ metres. How many ta’ovala does she make?

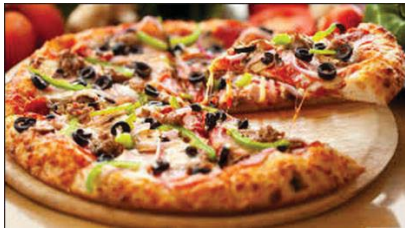
4. Twelve mamas are working together to make a big tivaevae. Each mama makes one patterned square. Each side of her square measures 0.75 metre. Teremoana has the job of sewing a border around the tivaevae after all the squares are joined together.



What will the area of the tivaevae be?

Can you record some possible lengths the border could be?

5. Shared lunch in N1



At the end of the term N1 has decided to have pizzas for their shared lunch. The class selected 3 people to be responsible for choosing the toppings for the pizzas.

Caroline orders 1 pizza, she asks for 20% bacon, $\frac{1}{5}$ chicken, 0.2 salami and the remainder cheese,

What portion of the pizza is cheese?

Eseta orders 1 pizza. She asks for 30% pepperoni, $\frac{6}{15}$ sausage, 0.3 green pepper and the remainder pineapple and bacon.

What portion is pineapple and bacon?

Tuineau orders 1 pizza. He asks for 12.5 % pepperoni, $\frac{3}{8}$ meat lovers, 0.25 supreme and the remainder cheese.

Extension

Caroline orders 7 pizzas, she asks for $12\frac{1}{2}\%$ pepperoni, $\frac{12}{32}$ meat lovers, 0.375 supreme and the remainder pineapple and bacon. What portion of the pizzas are pineapple and bacon?

Tuineau orders 10 pizzas, he asks for 15% meat lovers, $\frac{3}{12}$ chicken and cranberry, 0.125 supreme and the remainder pepperoni. What portion of the pizzas are pepperoni?

APPENDIX C – SCHOOL CONSENT FORM



Institute of Education
Tennent Drive
Palmerston North 4474

A case study on

CULTURALLY RESPONSIVE TEACHER ACTIONS TO SUPPORT PĀSIFIKA STUDENTS IN MATHEMATICAL DISCOURSE

CONSENT FORM: BOARD OF TRUSTEES

THIS CONSENT FORM WILL BE HELD FOR A PERIOD OF FIVE (5) YEARS

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: _____ **Date:** _____

Full Name – printed: _____

APPENDIX D– TEACHER INFORMATION SHEET / CONSENT FORM

CULTURALLY RESPONSIVE TEACHER ACTIONS TO SUPPORT PĀSIFIKA STUDENTS IN MATHEMATICAL DISCOURSE

INFORMATION SHEET

Dear Mr J

My name is Ingrid Cheung. I am a primary school teacher who will be on study leave from 2 March to 24 November to complete a thesis for a Master of Education at Massey University. My thesis is a qualitative study examining what teaching strategies support Pasifika students in mathematical inquiry. In particular your practice on scaffolding language to support Pasifika students to speak mathematically.

I am formally inviting you to be a part of this research in which I will examine the ways which best support Pasifika students to actively participate in a mathematics classroom. Your role in this project will be as the mathematics teacher - the main participant of the research.

Permission to participate in the study will be sought from both the parents/caregivers of the students in your class and the students themselves. The students and their parents/caregivers will be given full information and consent will be requested in due course. Consent will be twofold: one for individual interviews, and one for the video recording in class. I appreciate your help to pass on the information and collate the consent forms.

I will interview you and the students. These interviews will take place at the start of the investigation and towards the end of the investigation. The time involved for your interview will be no more than 20 minutes. The interviews for each student will also be no more than 20 minutes. The interviews with you and students will be audio/video recorded.

During this project, three consecutive mathematics lessons will also be videotaped at the beginning of the study, and three consecutive mathematics lessons will be videotaped every four weeks until the end of the study in June. The time involved in the complete study for you will be no more than 15 hours over a period of two school terms. Work samples from each lesson will also be collected and photo-copied. The interviews and observations of students will take place in the classroom and be part of the normal mathematics programme.

All project data collected during individual interviews and filming will be stored in a secure location, with no public access and used only for this research and any publication arising from this research. After completion of five years, all data pertaining to this study will be destroyed in a secure manner. All efforts will be taken to maximize confidentiality and anonymity for participants. Names of all participants and the school will not be used once information has been gathered and only pseudonyms and non-identifying information will be used in reporting.

Please note that you are under no obligation to accept this invitation. If you decide to participate you have the right to:

- Decline to answer any particular question;
- Withdraw from the study after four weeks;
- Ask any questions about the study at any time during participation;
- Provide any information on the understanding that your name will not be used unless you give permission to the researcher

- To ask for the audio or video recorder to be turned off at any time during the interviews and any comments you have made be deleted;
- Be given access to a summary of the project findings when it is concluded.

If you have any further questions about this project you are welcome to discuss them with me personally:

Ingrid Cheung. Phone: 021 061 0692 . Email: yningrid@yahoo.com.au

Or contact either of my supervisors at Massey University

- Associate Professor Roberta Hunter (09) 414 0800 Ext 9873 .
Email. R.Hunter@massey.ac.nz
- Dr. Jodie Hunter (06) 356 9099 Ext 84405. Email. J.Hunter1@massey.ac.nz

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director, Research Ethics, telephone (06) 350 5249, email humanethics@massey.ac.nz .

**CULTURALLY RESPONSIVE TEACHER ACTIONS TO SUPPORT PĀSIFIKA
STUDENTS IN MATHEMATICAL DISCOURSE**

CONSENT FORM: TEACHER PARTICIPANT

THIS CONSENT FORM WILL BE HELD FOR A PERIOD OF FIVE (5) YEARS

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/do not agree to the interview being sound recorded.

I agree/do not agree to the interview being video corded.

I agree/do not agree to be sound/video recorded in class.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: _____ **Date:** _____

Full Name – printed: _____

**APPENDIX E – STUDENT AND PARENT INFORMATION SHEET / CONSENT
FORM**

**CULTURALLY RESPONSIVE TEACHER ACTIONS TO SUPPORT PĀSIFIKA
STUDENTS IN MATHEMATICAL DISCOURSE**

INFORMATION SHEET

My name is Ingrid Cheung and I am a primary school teacher. I am doing a research project for a Master of Education at Massey University. I am going to look at how teaching strategies support Pasifika students to learn mathematics at school.

I would like to invite you with your parent's permission to be involved in this study. Your teacher Mr Downes has also agreed to participate in this study. The Board of Trustees has also given their approval for me to invite you to participate, and for me to do this research.

If you agree to be involved, I will speak to you about what helps you to learn maths in class. There will be several interviews; one will be at the beginning of my project, one will be after a few of your mathematics lessons, and the last interview will take place at the end of my project, which will be towards the end of term two. The interviews will take about 20 minutes each. The interview will be audio and video recorded and you may ask that the recorder be turned off and that any comments you have made be deleted if you change your mind or are not happy about what you said.

I will also be observing you participating in three mathematics lessons at the beginning of my project and then every fourth week until the end of the project. Mr Downes will be teaching you at this time and these lessons will be part of your normal mathematics programme, whether you agree to be in the study or not. These lessons will also be audio and video-recorded and you may at any time ask that the recorders be turned off and any comments you have made deleted. With your permission I might sometimes collect copies of written work or charts you make to support your mathematical thinking. You have the right to refuse to allow the copies to be taken.

Taking part in this research will not in any way affect your learning, but rather may help you clarify what help you learn in mathematics lessons. The interview and observations will take place in the classroom and be part of the normal mathematics programme.

All the information gathered will be stored in a secure location and used only for this research. After completion of the research the information will be destroyed. All efforts will be taken to maximize your confidentiality and anonymity which means that your name will not be used in this study and only non-identifying information will be used in reporting.

I ask that you discuss all the information in this letter fully with your parents before you give your consent to participate.

Please note that you have the following rights:

- To say that you do not want to participate in the study
- To withdraw from the study at any time
- To ask for the audio or video recorder to be turned off at any time during the lessons or interviews and any comments you have made be deleted

- To refuse to allow copies of your written work to be taken
- To ask questions about the study at any time
- To participate knowing that you will not be identified at any time
- To be given a summary of what is found at the end of the study

If you have any further questions about this project you are welcome to discuss them with me personally:

Ingrid Cheung. Phone: 021 061 0692 Email: ymingrid@yahoo.com.au

Or contact either of my supervisors at Massey University

- Associate Professor Roberta Hunter (09) 414 0800 Ext 9873 .
Email. R.Hunter@massey.ac.nz
- Dr. Jodie Hunter (06) 356 9099 Ext 84405. Email.
J.Hunter1@massey.ac.nz

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director, Research Ethics, telephone (06) 350 5249, email humanethics@massey.ac.nz .

**CULTURALLY RESPONSIVE TEACHER ACTIONS TO SUPPORT PĀSIFIKA
STUDENTS IN MATHEMATICAL DISCOURSE**

CONSENT FORM: STUDENT PARTICIPANTS

THIS CONSENT FORM WILL BE HELD FOR A PERIOD OF FIVE (5) YEARS

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/do not agree to the interview being sound recorded.

I agree/do not agree to the interview being video recorded.

I agree/do not agree to be sound/video recorded in class.

I agree to participate in this study under the conditions set out in the Information Sheet.

Child's Signature: _____ **Date:** _____

Full Name – printed: _____

**CULTURALLY RESPONSIVE TEACHER ACTIONS TO SUPPORT PĀSIFIKA
STUDENTS IN MATHEMATICAL DISCOURSE**

**CONSENT FORM: PARENTS/CAREGIVERS OF STUDENT PARTICIPANTS
THIS CONSENT FORM WILL BE HELD FOR A PERIOD OF FIVE (5) YEARS**

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/do not agree to _____ being sound recorded.

I agree/do not agree to _____ being video recorded in the interview.

I agree/do not agree to _____ being sound/ video recorded in class.

I agree to _____ participating in this study under the conditions set out in the Information Sheet.

Parents Signature: _____ **Date:** _____

Full Name – printed: _____