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Forging Mathematical Relationships in Inquiry-Based Classrooms With Pasifika Students

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In this article, the authors report changes in mathematical disposition, participation, and competencies within a group of Pasifika students as a teacher established the discourse of mathematical inquiry and argumentation. Within a classroom-based design approach, the teacher used a communication and participation framework tool to support students to engage in a range of collective mathematical practices. Drawing on analyses of student interviews conducted over one school year, the authors provide a narrative that illustrates how changes in agency and accountability accompanied shifts in the mathematical inquiry discourse. The results show positive learning outcomes for Pasifika students when the general and mathematical obligations attend to the cultural, social, and mathematical well being of all students in mathematics classrooms.

KEYWORDS: collaborative problem solving, culturally relevant pedagogy, educational change, inquiry communities, mathematics education, urban education

Inquiry-based classrooms position students as active participants in a community of learners. The belief is that active engagement will lead to the development of specific student dispositions and competencies that are presumed to make a positive difference in students' life chances and their future civic participation (Anthony & Walshaw, 2007; Goos, 2004). In the inquiry-based mathematics classroom students have a significant opportunity for engagement through activities involving mathematical discussion and argumentation. Collectively, research based in Western education systems (e.g., Cobb, Wood, Yackel, & McNeal, 1992; Forman & Ansell, 2001; Goos, 2004; Walshaw & Anthony, 2008), and in some Asian systems (e.g., Pang, 2009; Sekiguchi, 2006), advocate that effective pedagogy affords students opportunities "not only to share their ideas in a mathematical community but also to analyze and evaluate the thinking of other members"

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(Mueller, 2009, p. 138). Indeed, in a landmark study involving analysis of 42 mathematics lessons, Wood, Williams, and McNeal (2006) demonstrated that "those interaction patterns that required greater involvement from the participants were related to higher levels of expressed mathematical thinking by children" (p. 249).

There has been considerable attention within research literature to creating inquiry-based learning environments in which students not only express their own ideas but also use mathematical reasoning to challenge those of their peers and the teacher. There are a number of studies that provide exemplars of professional development programs to support reforms toward more inquiry-based practices (e.g., Hunter, 2008; Sherin, Linsenmeier, & van Es, 2009), and exemplars of inquiry-based classrooms in practice (e.g., Kazemi & Franke, 2004; Staples & Truxaw, 2010). This critical mass of studies has enabled detailed analysis of those teacher practices that facilitate effective mathematical discourse patterns—both in group work activities and whole-class discussions. For example, Walshaw and Anthony's (2008) review of classroom discourse highlights the teacher's role in establishing participation norms, in supporting and fine tuning mathematical thinking, and in shaping mathematical argumentation. Similarly, Stein, Engle, Smith, and Hughes (2008) offer five key practices that teachers can use to orchestrate class discussions: anticipating, monitoring, selecting, sequencing, and making connections between student responses.

However, these studies also highlight that incorporating practices of inquiry learning is challenging. In some cases, the intentions of equitable and inclusive participation are compromised. For example, Planas and Gorgorió's (2004) classroom study illustrated the ways in which one teacher regulated participation by creating inconsistent rites across student groups. The researchers observed the teacher's subtle systemic refusal of immigrants' attempts to explain and justify their strategies for solving problems. Other studies (e.g., Ball, 1993; Baxter, Woodward, & Olson, 2001) note the ways that highly articulate students can dominate discussions while "low achievers" may choose to remain passive. In collaborative group work there is potential for unintended learning—students may learn incorrect mathematical strategies (Good, McCaslin, & Reys, 1992) or inappropriate social behaviors (Hand, 2010). Of more concern is that for some students the expected mathematical practices—such as constructing representations, making arguments, and explaining their thinking—may be difficult or make them feel uncomfortable. As Esmonde (2009b) notes, this is particularly so "if these practices are not common or they are interpreted differently in other community practices" (p. 1011). Given these challenges, studies that provide insight into learning mathematics in inquiry-based classrooms from the perspective of the students, while less common, are particularly important.

In New Zealand, similar to many countries, we have an increasingly diverse student population. And similar to some other countries, it is clear that our education system has some way to go to meet the needs of *all* learners (Bishop, Berryman, Cavanagh, & Teddy, 2009). Despite recent large-scale implementation of professional development opportunities in mathematics education (see Higgins & Parsons, 2009), we continue to record significant levels of underachievement for students who are from marginalized backgrounds. This underachievement includes a large percentage of Pasifika students in New Zealand schools (Young-Loveridge, 2009), students who are the focus of this study. In facing the challenge to address the low and inequitable mathematics performance of groups of students, Boaler and Staples (2008) urge researchers to gather more evidence on the ways that mathematics may be taught more effectively in different settings and circumstances. For our part, in looking to redress the inequitable opportunities afforded Pasifika students in low decile[1] schools (Ferguson, Gorinski, Wendt-Samu, & Mara, 2008), we collaborated with four teachers to explore how to enact inquiry teaching and learning practices that support students' development of mathematical proficiency. In this article, rather than focusing on how the teachers (re)arranged their learning environment, we center our discussion on the students' perceptions of "being" mathematics learners in this changing environment. In examining closely how previously disaffected students come to develop productive relationships with both mathematics and with themselves as mathematical learners, we seek to understand more about the way learning—in all its forms—is occasioned within an urban mathematics classroom.

Forging Relationships *with* and *in* Mathematics

The idea that teaching and learning are located within a complex social web draws its inspiration from Vygotsky (1986) and the work of activity theorists. This body of work proposes a close relationship between social processes and conceptual development and is given a clear expression in Lave and Wenger's (1991) well-known social practice theory, in which the notions of a community of practice and the connectedness of knowing are a central feature. As Walshaw (2007) explains, social theories of learning suggest that thinking, meaning, and reasoning are constituted socially in a mutually relational manner—that is, "the learner is inextricably *connected to* a dynamic social context" (p. 35). Instruction that provides opportunities for students to engage in mathematical inquiry and in meaning making through discourse necessarily requires opportunities for learning in a social environment. Through collaborative engagement in the context of shared activities and interests, students engage in discourse practices that involve the articulation and justification of their mathematical thinking.

[1] Schools in New Zealand are ranked into deciles (low to high) as an indicator of the socio-economic level of the school community. The lowest decile ranking is a decile 1; the highest is decile 10. Students of Pasifika ethnicity predominantly attend schools within decile ratings of 1–3.

To understand more about the interaction between students' relationship with mathematics and the learning opportunities afforded the students in this study, we draw on Cobb, Gresalfi, and Hodge's (2009) analytic framework of the relation between the microculture established in a particular classroom and the students' developing personal identities. In explaining "how it is that students come to understand what it means to do mathematics as it is realized in their classroom and with whether and to what extent they come to identify with that activity" (p. 41) they highlight the role of classroom obligations—both general and mathematical—that are constituted in the course of the ongoing classroom interactions. Obligations comprise both the "general and the specifically mathematical obligations that delineate the role of an effective student in a particular classroom" (p. 43). General obligations concern the *distribution of authority* and the ways that students are able to *exercise agency*. Mathematical obligations concern the "norms or standards for mathematical argumentation and normative ways of reasoning with tools and written symbols" (p. 45).

The complex web of relationships surrounding the organization and facilitation of knowledge production collide with students' developing mathematical disposition, competence, and participation within the activity system of their classroom (Esmonde, 2009a). Here, we use the conceptual frameworks of disposition, competence, and participation to interpret students' perceptions of their relationship with and in mathematics.

Disposition

Disposition, as we use the term, is set within the context of classrooms and constructed within a set of practices that are realized within the immediate classroom activity setting in which the mathematics teaching and learning takes place. Students develop a mathematical disposition—that is a collection of notions about mathematics, the values of mathematics, and ways of participating in mathematics—in and through classroom activity (Gresalfi & Cobb, 2006). The idea that students learning "to do mathematics" is inextricably linked with their learning "to be mathematical" is clearly recognized in current mathematics education literature. Studies (e.g., Boaler, 2002; Lampert, 2001; Staples, 2008) illustrate how the role of authority, as exercised by teachers in classrooms, plays out in students' ideas, values, and ways of participating in mathematics. Boaler (2002), in her comprehensive study of mathematics classes in two different types of schools, illustrated that student opportunity to interact with, and in, mathematics was constrained in classrooms where teachers maintained a high degree of authority, particularly in relationship to determining preferred methods and correctness of procedures. In such settings, students constructed beliefs about their role as secondary to that of the teacher, and saw themselves as passive, non-questioning recipients of mathematical knowledge. The contrast is in classrooms where authority is distributed more evenly among teachers and students. Boaler illustrated how in settings where students were obliged to construct their own problem solving strategies, validate their reasoning, and regulate their behavior, they constructed different relationships with and in mathematics. They developed positive mathematical dispositions, which led to increased motivation to engage with mathematics at deeper levels. In this article, we examine how students' dispositions changed as they aligned their ways more closely to the norms of practices of inquiry-based learning.

Competence

Rather than defining competence as an attribute of the individual—the "what" a student needs to know or do in order to be considered successful—we draw on Gresalfi, Martin, Hand, and Greeno's (2009) notion of "systems of mathematical competence" (p. 49). Constructed in classroom interactions, the "opportunities for students to be understood as being competent depend on the tasks that they are assigned to work on, and on the agency and accountability with which they are positioned to do that work" (p. 67). For example, in one class, competence may be determined by using the right methods, and in another class, students may be constructed as competent when they participate in acts of sense making. Importantly, within the social network of the classroom (and beyond) the teacher and the students are both central players in constructing competence. Here, we illustrate how some of the students shifted in perceiving competence as a fixed attribute of themselves as individuals to view competence as related to their role and learning associated with specific activities as expressed by the perceived mathematical obligations (Cobb et al., 2009).

Participation

Drawing on the perspective of Lave and Wenger (1991), learning can be defined as a change in participation in a set of collective practices. In mathematics, learning has come to be conceptualized as learning to participate in mathematical practices—the "ways in which people approach, think about, and work with mathematical tools and ideas" (RAND Mathematics Study Panel, 2003, p. xvii). In inquiry-based classrooms, learning to participate in mathematical practices involves learning to construct representations, make arguments, reason about mathematical objects, and explain one's thinking. Rather than be on the periphery of participation, or constantly needing support, Esmonde (2009b) argues that "the goal is for learners to adopt central participation without the teacher's direct help" (p. 1011). She notes, for example, that "we need to look to see whether all forms of student participation allow students to move on a trajectory towards more central and competent participation in classroom practices" (p. 1011). However, in moving toward those mathematical practices advocated in inquiry learning we need to be aware of the relational aspects involved in participation. For example, when working on problem solving tasks, forming and defending mathematical conjectures, and discussing with their peers, students need to be willing and able to engage in areas in which they are only partially competent (Gresalfi et al., 2009). Such engagement is likely to evoke a range of emotions such as, excitement, satisfaction, and frustration. Bibby (2009) claims that relationships characterised by issues of emotion and trust actually frame what is knowable. For her, effective pedagogy needs to engage with the emotional labor and risk involved in trying to mutually understand something (and each other), and it must recognise the pain that constitutes not knowing.

In this article, we examine how students took up or resisted opportunities to participate in ways advocated for by the teacher as he established inquiry-based learning.

Pasifika Learners in the New Zealand Context

As stated earlier, here we report on a group of Pasifika students. The term *Pasifika*, as we use it, refers to a multi-ethnic, heterogeneous group of people who originated from the Island nations in the South Pacific. In New Zealand, Pasifika students as a group exhibit significantly lower achievement results in mathematics than their European New Zealand counterparts (Crooks, Smith, & Flockton, 2010; Ferguson et al., 2008). Most of the Pasifika population resides in an Auckland region, which has the highest birthrate and holds the bottom ranking on all national indices including education (Airini et al., 2007).

Although Pasifika learners are a diverse group, Anae, Coxon, Mara, Wendt-Samu, and Finau (2001) draw attention to a set of cultural commonalities within Pacific values, which include "respect, reciprocity, communalism, and collective responsibility" (p. 14). These core values, whilst respected in culturally responsive pedagogical practices, may not initially be aligned with having students feel comfortable participating in problem-based mathematical activity and inquiry. For example, in considering the concept of respect, Jones (1991) and Clark (2001) describe how Pasifika students in their studies identified listening to the teacher as an appropriate way to learn. The students considered the teacher to be their elder and therefore their knowledge unquestionable. Likewise, the students viewed arguing with, or asking teachers questions, to be disrespectful because it was their responsibility to listen closely and learn from the teacher. Awareness of these "cultural-historical repertories" (Guitiérrez, & Rogoff, 2003) and encouragement for learners to "develop dexterity in determining which approach from their repertoire is appropriate under which circumstances" (p. 22) are important equity considerations for socializing students into mathematical inquiry discourse (Boaler, 2006; Gutierrez, 2002; MacFarlane, 2004).

Specific to the New Zealand context, MacFarlane (2004) advocates culturally responsive teaching which carefully structures student access to learning spaces that are "culturally as well as academically and socially responsive" (p. 61). In this study, a key consideration was given to balancing the Pasifika students' beliefs with developing their participation and competence in inquiry discourse as a "social language" (Gee & Clinton, 2000, p. 118). Social language, as Gee and Clinton use the term, refers to ways of "talking, listening…acting, interacting, believing, valuing and using tools and objects, in particular settings, at specific times, so as to display and recognize particular socially situated identities" (p. 118). Other researchers (e.g., Ferguson et al., 2008; Hawk, Tumama Cowley, Hill, & Sutherland, 2005) highlight the problems caused by formality and competition in New Zealand classrooms. They argue for classrooms to be more inclusive and to build on the cultural capital of Pasifika students—and respect their concept of community and collectivism.

In addition to the possibility that Pasifika students are immersed in curriculum and pedagogical practices founded in Euro-centric precepts (Tate, 1994); they may also encounter hurdles related to low socioeconomic backgrounds. Lerman (2009) uses Bernstein's theory to highlight how pedagogic discourse makes certain subjectivities available to middle-class students by establishing pedagogical relations that are highly "visible"—and similar to that which they have already experienced in the home. In such a classroom, "being" mathematical is more difficult for students from working-class and culturally different backgrounds, who are less likely to recognise what mathematical knowledge should be engaged in within a given situation and are less likely to realize the required "appropriate" behaviors.

As a way forward, Boaler and Staples (2008) argue that pedagogical practices that "evince social awareness and cultural sensitivity are critical if the desired outcome is student participation and academic success" (p. 612). In New Zealand, Hunter's (2006, 2007, 2008) study illustrates the positive outcomes for Pasifika students when teachers explicitly build on the Pasifika values of reciprocity, communalism, and collectivity while sensitively observing the students' notions of respect. In these classroom studies, Pasifika students were positioned to engage in inquiry discourse and develop collective mathematical practices within a carefully crafted learning environment. Responsive and caring relationships between the teachers and students in the classrooms were central in overcoming disparities and increasing inclusivity. As Tate (1994) explains, "connecting the pedagogy to the lived realities…of the students is essential for creating equitable conditions" (p. 478). The focus of Hunter's studies however were on the actions the teachers took to construct communities of mathematical inquiry with diverse learners. Our most recent study on inquiry classrooms provides an opportunity for us to hear the students' voice and understand from their perspective how they view their relationship as users and doers of mathematics.

The Study

In this article, we draw on data from one classroom within a classroom-based design study (Design-Based Research Collective, 2003). The wider study was situated in two New Zealand schools in an urban low socio-economic area (decile 1 and decile 3) where the large majority of students were of Pasifika ethnicity. The aim of the study was to examine pedagogical practices that optimize equitable access to increasingly sophisticated forms of mathematical practices within inquiry-based classrooms. The trial of a communication and participation framework (CPF), designed to support teachers to scaffold student participation in a range of mathematical practices, was a key feature of the study. This tool (see Appendix), adapted from the theoretical framework proposed by Wood and McNeal (2003), details a set of collective reasoning practices related to the communicative and performative actions that support effective mathematical inquiry practices (for further details of the design of the CPF tool see Hunter, 2007, 2008). Over a period of one year, the teachers used the CPF as a tool to prompt and monitor student engagement in inquiry practices. As the study progressed, associated changes in social and sociomathematical norms supported students to make increasingly proficient mathematical explanations, representations, justifications, and generalizations.

The Case Study

Over the course of the study, the teachers and their students adapted and adopted the practices detailed in the CPF in various ways. Thus any analysis of student perceptions of their relationships with mathematics and with themselves as mathematical learners is bound by context. Here, we have selected one case: a classroom of 20, eleven- to twelve-year-old students and their Pasifika teacher. The students in this class were predominantly of Pasifika ethnicity. The pedagogical changes in the selected case exemplified significant shifts toward inquiry-based classroom practices as per the aims of the study. Over the course of the school year, the teacher consistently pressed the students to develop the social and sociomathematical norms of mathematical inquiry. As part of his efforts, he drew on his own cultural knowledge to frame the social norms within social and cultural contexts that were familiar to the students. For example, the requirement that students work collaboratively was framed within an appropriate cultural setting (preparing an umukai [village feast] and the collaborative roles all participants hold). He guided student attention toward Pasifika concepts of reciprocity, communalism, and collectivism as he had them develop mathematical explanations, representations, and justification within their groups. He drew on their concept of respect and reciprocity as part of their need to actively listen, question, offer help, check the understanding of all members of the group, and support each other when reporting back to a wider audience.

Data for the case study were collected from multiple sources over the timeframe of the school year; it included field notes, classroom artifacts, teacher interviews, and video and digital photo records of 10 mathematics lessons (with a focus on the teacher establishing small group and large group mathematical activities). Immediately after each of the observed lessons, the four to six students who were the focus of the video capture were invited to participate in individual semi-structured interviews. The interviews provided opportunities for students to reflect on their role within the group and classroom activities experienced that day. Additionally, in each of the interviews, students were asked to discuss how they were feeling about learning mathematics in this classroom.

The data analysis we present here draws primarily on the audio-recorded interviews with the students. The first phase involved open coding (Strauss & Corbin, 1998) of the interview transcripts to look for emerging themes informed by our conceptual framework. A concurrent analysis of the video records and field notes of classroom episodes enabled us to compare and refine emerging patterns and themes in the interviews alongside shifts in the social and sociomathematical norms of the classroom. We have used this analysis to provide a collective narrative—presented as a trajectory—of student perceptions of their relationship with and in mathematics.

Student Voices: Relationships *with* and *in* Mathematics

At the beginning of the school year (the initial phase of the study) the pedagogical patterns used by the case teacher conformed to a more traditional pattern. The teacher taught content that consisted of preplanned numerical strategies in a procedural manner. Any discussions about the strategy solutions typically followed an Initiate-Response-Evaluate (I-R-E) structure (Mehan, 1979); that is, he initiated questions about the mathematical reasoning (mostly at the level of explanation of strategy steps), nominated who should respond, and then he took the responsibility for evaluating the responses. The students responded to his questions but they did not ask additional questions nor shift the discussion to other mathematical content or different ways of reasoning.

Initial Relationships

Interviews with 12 students (assigned pseudonyms) conducted within a month of the project beginning (early in the school year) indicated that the students held a range of views towards mathematics and how they saw themselves as mathematics learners. Mele and Tarai stated that they liked mathematics but they could not describe why they liked it other than they found it "easy." The remaining students either stated that they did not like mathematics or they expressed ambivalent views about their liking for, and relationship with it. For example Mereana explained: "I like it a little bit. It is all right. It helps me learn new strategies. But then I sort of understand and then I don't, not all the time, just the hard work sometimes." Their explanations for not liking mathematics appeared to centre on their perceived inability to make sense of what the teacher explained. Tama stated:

> I know that I am not that good because I know because I just get lost and confused. I get confused easily when I am doing maths. When I see too much numbers they just get all muddled up in my head and I cannot add them together or stuff.

When describing how they could help themselves to learn mathematics, their responses suggested they held a view of themselves as passive participants in the learning process. They outlined how for them learning mathematics entailed listening to the teacher, working hard, and paying close attention to what the teacher said or did. Similarly, they all reported that when they got stuck completing a mathematics task they asked the teacher for help. In contrast, they described their teacher's role as an active one in helping them learn mathematics. They considered that it was his responsibility to tell them what to do, explain the mathematics, show them a range of different strategies, and question them. These views are well captured in Mereana's description of the day's lesson where even when the teacher explicitly directed the students to actively participate and ask questions; but, by default, question asking still remained the responsibility of the teacher:

> We did fractions and he showed us strategies to do and we talked about them with the whole class and we sort of had to ask questions but the teacher asked the questions.

Beginning to Change

The initial focus of the inquiry intervention involved establishing new arrangements for learning. Early in the school year, the teacher introduced a lesson format in which students first worked in small problem solving groups to construct mathematical explanations followed by presentation of their work to a larger group. Group worthy contextualized problems[2] were used, and the students constructed ways to represent their reasoning. When interviewed about this new

[2] For example, Moana used 12 rolls of gift wrap to make 18 skirts for the Trash to Fashion show. How many rolls of gift wrap would she need to make 21?

arrangement, the students were unanimous in their preference for working together as a small group. They outlined how the smaller group provided opportunities to learn from each other, noting that they now regarded mathematics as more difficult to learn on their own. In this early stage of working collaboratively, students indicated a strong preference for working with the same people all the time (or with friends).

While social arrangements were affirmed, views about the nature of involvement of expected mathematical practices were more tentative. Confidence in one's competence to provide a mathematical explanation, even in a small group situation, posed problems for many: "It is quite difficult because I am not good at explaining things" (Ana). While many reported uncertainty about their ability to speak and explain their mathematical reasoning in a small group, all of the students attributed a lack of confidence when required to speak to the larger group. Commonly, a reticence to explain due to shyness was coupled with the students' need to maintain "face" both as individuals and as representatives of the group. For instance, the tensions experienced by Sione were evident when he is asked to reflect on a photograph of himself providing an explanation. He recalls his feelings at that moment as being concerned that

> I better not muck this up. That is what is going through my head. I better not muck this up and if I do everyone is going to look at me; like, I have just got it wrong.

Upon viewing the photograph of this classroom episode, the other students who were listening to his explanation talked about the difficulties they had participating and actively listening and making sense of his reasoning. Mahine stated that because Sione's reasoning was new, it was too difficult and confusing to understand. Another student, Dan, described his "listening" as cuing his own thinking rather than active engagement in the reasoning being offered: "I was trying to work out how we got our equation as they were explaining. I was listening but thinking about our work."

To increase student sense making of mathematical explanations, the teacher had introduced space during presentation of explanations to enable them to question parts they found confusing. However, all the students described feeling a lack of confidence to construct and ask questions during discussions: "When we are talking in a big circle there are too many people and so I do not ask a question" (Mahine). Although they recognised the importance of asking questions for sense making their responses indicated that constructing appropriate questions posed difficulties. For example, when asked why they needed to ask questions, Mereana explained: "So I can understand better, but it is not really easy to ask questions. It makes it hard by figuring out what to ask."

Moving Along the Change Trajectory

As the learning environment moved more toward an inquiry-based classroom, so did the students' relationships with and in mathematics change. In contrast to earlier accounts, all the students described their enjoyment in learning and being challenged in mathematics. Reasons for liking mathematics varied but a common factor related to their feeling of mathematical capability associated with increased knowledge of strategies and ways of using them while problem solving.

Now, when the students were asked who helped them to learn mathematics during the lesson, they attributed their learning to the teacher, their classmates, and themselves. Clearly, they felt part of a community where learning mathematics was an active process that involved them engaging with their own reasoning and the reasoning of others. For example, Tere, in response to being questioned about whether she had previously learnt from other group members and the teacher, stated: "I tried to but I didn't know what they were saying. But now I ask myself some questions about what they are saying. Like some things about the numbers."

The positioning of members of the classroom community had changed. They were taking increased responsibility for their own learning and the learning of other members of the group and they viewed the teacher's role as one in which they worked with him as active partners:

> Our teacher gives [a problem] to us and instead of just showing us a way to work it out, we have to get it in our group and then by writing it with him [reference to the teacher facilitating public sharing in plenary], and I get it now. (Tama)

A sense of their own, and their shared responsibility in the learning process, was evident when Tama elaborated which of his group peers were involved in forming and writing the mathematical explanations: "With my group pretty much, all of us because we are in the same group."

As noted by Matiu, group work remained a positive feature of students' learning experience:

> Working in the group, I have never actually been good at it in previous years. But this year, it has been a lot better because I have people to help me and I learn different strategies from other people. Working in a group this year has been important for my learning and that is what is helping me.

However, in affirming the value of working in small groups, the following response by Hemi exemplified how students now recognised that collaboration while an important way of helping also afforded them with opportunities to deepen their own understanding:

> Well, we had Maurima in our group today and he was struggling with the maths and so he was going the hard yards and adding all the information in. And his questions, because he didn't have the knowledge we had, made us understand better because it was like having somebody fresh in and he was keen and ready to go with lots of questions.

Now, students also indicated that they readily accepted working with a range of peers: "I like working with lots of different people because it shows me how we can work with our friends" (Koru). Not only were students aware of the benefits of social and relational aspects of group work but also they were keenly aware that collaboration supported their use of effective mathematical practices. All the students used inclusive talk to describe their responsibility to construct a mathematical explanation that they could all understand and explain to the larger sharing group: "Yes, so the other groups understand what *we* are saying, what *we* mean from this" (Mereana).

A number of students described their gradual growth in confidence to speak and explain their mathematical reasoning. Regarding the small problem solving groups as a safe setting for them to risk take—students were more comfortable in constructing and trialing the initial presentation of their explanations. Their description of this change revealed an increased awareness of the value of being part of a community of learners. They expressed value in having their teacher hear what they knew, and value in sharing their reasoning, and value in teaching and helping other participants in the group to learn: "It is just like if someone gets confused then you are there to help them where they are going and things like that" (Ana). They indicated their acceptance that some listeners might be confused and that their explaining could help clarify their understandings, particularly if they asked questions: "You can teach other people like if they do not know and when they ask questions you can teach them what they don't know" (Hemi). At the same time they outlined the mutual responsibility for their own learning and the learning of others' as central to group activity:

> It is just like saying you don't really get it and then others help you. Your team helps you to explain it for the bigger group. You are learning by building your confidence. You are learning as well because you are working out a problem, you are working out a problem and you are speaking at the same time. Before you speak, you have to think and work it out first. (Ana)

Notably, students now viewed presentation of mathematical explanations to the large sharing group as an important part of their learning.

The importance of asking questions in both the small and larger group was also readily acknowledged by the students. They stated an increase in confidence and competence to ask questions. However for some, like Mele below, concerns remained, particularly in regards to protecting the self-esteem of other members of the group:

> I find it a bit challenging as well because you are asking the questions but they might not have the answer. There are some bits that we do not understand and we have to ask, "Where did they get it from?" in the small group and in the bigger group.

As well as asking questions, students were learning to engage in mathematical argumentation as they expressed agreement or disagreement with other students' assertions. Tarai noted:

> You could have others with different types of answers, some could disagree and some could agree. But then if you disagree you have to give an explanation on why you disagree.

However, at this stage, agreeing or disagreeing with the reasoning of others was problematic for many students. Matiu's statement captures this tension:

> It is good to disagree if you strongly believe that it is not right, that the answer is not right. As long as you are not doing anything wrong it is good to friendly argue. It is like the teacher says friendly arguing

In summary, within the mid-phase of the intervention, students showed an increased awareness and understanding of the role of mathematical argumentation. But it was still not part of their everyday repertoire of readily accepted actions, and held the potential to cause a loss of confidence. As Mele stated: "It made me think better but it is a bit scary."

Continuing on the Change Trajectory

At the conclusion of the school year, interview responses indicated that the students had made significant progress toward enacting the mathematical practices detailed on the CPF framework. The students outlined their confidence to explain, question, learn from mistakes, and use "friendly arguing" to achieve group agreement or to provide mathematical justification. They talked about how they liked to have time to complete their mathematics independently as well as working within a group. Group work they now described as important when the mathematical activity was difficult. They outlined how, in group interactions, the multiple sources deepened their learning: "So you get different answers and different questions from your group members" (Tarai). They also recognised the positive effects of listening to more proficient explanations and having their reasoning extended in the larger group setting: "I didn't really get it [what helped] was working in our group and then the other group made us think even higher when they explained it" (Teresa).

They accepted initial confusion and being stuck as part of their learning. But at the same time, they recognised their emotional reaction when stuck, as Hine described:

> I would be good with my basic facts and stuff but when it gets harder I just break down. I get stuck and I get shocked sort of. [Then] I go back and think again.

Now, they had a range of ways to participate and meet mathematical challenges head on. These included discussion with other individuals, the teacher, their group, or with themselves. The teacher was positioned as only one source (among others) to draw on and they described how they requested his help only when they were really stuck. They stated that they only wanted clues from him to get them started but would not learn if he detracted from their struggle by giving too much information:

> I prefer to work with the group and struggle but get a little bit of help, just a little bit of help not the whole lot. [If the whole lot is given] I would just forget straight away. I would not remember because I have not struggled. (Mele)

For Mele, the view of struggling as an essential component of learning (Heibert & Grouws, 2007) is captured as she continues and describes what mathematics means for her: "It is about working out problems that are challenging and struggling, struggling well, it is to get somewhere further than you are. Struggling is learning."

In summary, the roles of all participants in the classroom had been transformed. It was evidenced from the students' responses that their active role in the classroom included taking ownership of their learning across a range of aspects of mathematical practices. Their need for active involvement in learning is well captured in a Tama's comment:

> If you get involved, you will know lots about maths, and if you know lots, you will be successful. It's like tell me I will forget, show me I might remember, but if you involve me, I will learn lots.

Discussion

Clearly, students can change their relationship with and in mathematics. In our case classroom, the students' voices provide insight into the ways they changed how they came to understand what it means to both learn and do mathematics. To understand more about the students' changing relationship with mathematics, we return to Cobb et al.'s (2009) analytic framework based on the general obligations—concerning the distribution of authority and the ways that students are able to exercise agency and the mathematical obligations—concerning what counts as being mathematically competent within the classroom. In our case classroom, the teacher took great care to socially negotiate the obligations in a manner that was responsive to students' cultural histories and valued practices. His careful and consistent shift in positioning from a central role of authority and agency to one which was shared, and indeed expected of all participants, was reflected in the students' voices. As a result, the students developed increasingly more positive mathematical dispositions and their motivation to engage at progressively deeper levels increased. Their change in disposition was embedded within and inextricably linked to their shift in authority and agency in the classroom.

The classroom norms that held *all* students accountable for their own sense making and the sense making of others during mathematical activity were a pivotal factor in the strong sense of competence established by community members. As Gresalfi and her colleagues (2009) suggest, opportunities for students to be seen as competent rely on assigned mathematical activity and how the students are held accountable for completion of it. In the case classroom, both the general and mathematical obligations associated with group mathematical activities shifted as the year progressed. As the teacher devolved responsibility for the solution strategies, it is evident that there were clear shifts in how the students viewed their competence to participate in the mathematics. Initially, they considered the skill of listening and watching the teacher show them a solution strategy demonstrated competence (or incompetence) to learn mathematics. Over time, however, they reconstructed this passive approach to learning to one in which competence was interpreted as active construction of mathematical meaning through participating in interactions with others using a range of mathematical practices.

The students' narratives of their learning experiences showed increased awareness of their role in the participatory practices of inquiry group work activities. Their accounts reflected an increased confidence in their competence to be a useful and valued contributor in the learning community, alongside an increased awareness of and propensity to utilise productive mathematical practices as part of learning and doing mathematics. At the same time, their statements draw attention to the relational aspects that need to be considered when requiring students to participate in mathematical practices. The students initially voiced reluctance to participate in such mathematical actions as formulating and making conjectures, asking questions, or forming agreement or disagreement when not completely confident in their adequacy to do so. However, the perceived risks gradually diminished as the students (as individuals and as a collective) gained competence and were confident to participate in a variety of ways. Nonetheless, for many students, even when they felt confident and competent to use a range of different mathematical practices, questioning and challenging others, and, in turn, being questioned or challenged by others, remained an emotionally charged activity. Their descriptions of their reactions in the final interviews serve to remind us of the need for teachers to carefully consider what Bibby (2009) describes as the emotional labor and risk involved for students in participating in development of mutual mathematical understandings. Heeding Esmonde's (2009b) caution that different practices in different social and cultural groupings may be interpreted differently, one needs to be aware that many practices (here examples include questioning, agreeing, disagreeing, and challenging) are not common experiences for all students. Here, there is evidence that the students acknowledged inquiry and argumentation as beneficial for their learning but they recognised their novice status in engaging in inquiry and argumentation—practices they were not familiar with or necessarily comfortable with using. They also held concerns over how others in the classroom community might interpret their intent when using these practices.

Whilst the main purpose of this article is to examine how students' viewed the changes in their learning environment, as a way to understanding changes in their relationships with and in mathematics, we return at this point to the nature of the intervention. Our assertion is that the case teacher (and students) successfully over time created an environment that supported inquiry learning and the risks inherent in being held accountable for one's own learning and the learning of other members of the community. We make this assessment based on the observed pedagogic enactment of the communication and participation framework (CPF). Through the use of this tool, the teacher attended to building the students' use of inquiry discourse. As evidenced in student descriptions, this building resulted in them gradually developing what Gee and Clinton (2000) term a social language: ways of talking, acting, and doing mathematics within an inquiry environment.

Changes were reflected in the negotiated general and mathematical obligations that enabled these Pasifika students to act as instructional agents. Contributing pieces of mathematical knowledge and more advanced understandings held by different group members were combined to construct and progress a collective understanding. Each member of the group was considered a knowledge component of the collective and accountable to the collective to participate and use the mathematical practices competently. In turn, the teachers' responses tended to be directed more to a "collective student." In other words, for each contribution, the teacher sought to draw out implications for the learning of the whole class, rather than for each individual student.

Conclusion

Enacting culturally responsive teaching to enable all students to participate and contribute competently in mathematics classrooms is a key equity issue (MacFarlane, 2004). In the case classroom, the teacher drew on the cultural capital of the Pasifika students and the core Pasifika beliefs of reciprocity, collectivism, and communalism to frame both grouping arrangements and expected behaviors. In addressing the group norms for collaborative interactions, the teacher created a space for all participants to have opportunities to engage in equitable exchanges. Within this environment, students constructed views of themselves as both competent individual learners and competent learners within collectives. For the most part, their accounts indicate awareness of changes in their relationship with and in mathematics.

These findings have important messages for addressing the pressing concern of equitable participation of diverse learners in the mathematics classroom. They provide evidence that when general and mathematical obligations attend to the cultural, social, and mathematical well being of students, inquiry-based classrooms can be empowering and positive for students who have previously been marginalized. In this study, creating a mathematical community of inquiry that was culturally inclusive supported students to be powerful mathematics learners—as reflected in their positive mathematical dispositions, their sense of competence, and their active participation in collective mathematical practices.

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APPENDIX

A communication and participation framework to engage students in mathematical practices within an inquiry classroom:

Develop conceptual explanations, including using the problem context to make explanations experientially real

- Provide a mathematical explanation. Use the context of the problem not just the numbers. Provide mathematical reasons (e.g. rather than "tidying," state 19+7=20+6 because 6+1=7 and 19+1=20).
- Develop two or more ways to explain a strategy solution.
- Analyse the explanation and construct ways to revise, extend, and elaborate on sections others might not understand.
- Predict questions that will be asked and prepare mathematical responses.

Active listening and questioning for sense making of an explanation

- Ask questions that clarify an explanation (e.g., What do you mean by? What did you do in that bit? Can you show us what you mean by? Could you draw a picture of what you are thinking?).

Collaborative support and responsibility for the reasoning of all group members

- Agree on the construction of one or more solution strategies that all members can explain.
- Work together to check, explain, and re-explain in different ways the group explanation.

Develop justification and mathematical argumentation

- Indicate agreement or disagreement (with mathematical reasons) for part of an explanation or a whole explanation.
- Justify an explanation using language (e.g., I know 3+4=7 because 3+3=6 and one more is 7).
- Use exploratory language (e.g., so, if, then, because, to justify and validate an explanation).
- Use questions that lead to justification (e.g., How do you know it works? Can you convince us? Why would that tell you to? Why does that work like that? So what happens if you go like that? Are you sure it's? So what happens if? What about if you say…does that still work?).

Develop representations of the reasoning

- Represent reasoning as part of exploring and making connections (e.g., How can I/we make sense of this for my/ourselves?).
- Represent reasoning to explain and justify the explanation (e.g., How can I explain, show, convince other people?).
- Use a range of representations including acting it out, drawing a picture or diagram, visualising, making a model, using symbols, verbalising or putting into words, using materials.

Develop generalizations

- Extend the explanation and/or justification to a representation of the mathematical relationship in general terms.
- Identify the rules and relationships through making and extending the connections.
- Use questions that lead to generalisations (e.g., Does it always work? Can you make connections between? Can you see any patterns? Can you make connections between? How is this the same or different to what we did before? Would that work with all numbers?).