

Developing Adaptive Expertise with Pasifika Learners in an Inquiry Classroom

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In the current reform of mathematics classrooms teachers are charged with the role of facilitating collaborative groups during problem-solving activity. The challenge is for teachers to engage students in making mathematical meaning during collaborative group discussions. In this paper we draw on the concept of adaptive expertise to report on teachers' actions to engage students in co-constructing collective knowledge. We address how teachers attended to students' cultural values and socio-mathematical norms to promote and cultivate adaptive expertise.

Introduction

The current educational climate emphasises children in the 21st century becoming literate and numerate (Ministry of Education, 2010). Despite this aspiration, within New Zealand the National Standards data highlights the significant underachievement of many Pasifika students (Ministry of Education, 2012). Many researchers (e.g., Berryman, Bishop, Cavanagh, & Teddy, 2009; Clark, 2001; Spiller, 2012) note that Pasifika students along with indigenous Maori students are marginalised in the schooling system due to inequitable practices. This includes deficit theorising by teachers, identity issues, lack of effective pedagogical actions, and cultural misunderstandings. In order to alleviate these practices and increase the achievement of Pasifika learners, New Zealand's national Pasifika education strategy – the *Pasifika Education Plan (PEP) 2013 – 2017* emphasises the need to increase achievement by responding to the identities, languages, and cultures of different Pasifika groups (Ministry of Education, 2013).

The PEP policy is prominent at a government level; however, there are limited guidelines for schools and teachers on how to implement the goals of the strategy. Furthermore, few studies specifically focus on culturally responsive practices for Pasifika learners in mathematics. Research studies (e.g., Averill & Clark, 2012; Hunter & Anthony, 2011) which do address this area indicate that cultural values can work against Pasifika students as they are not accustomed to questioning or arguing during mathematics - practices integral to success in mathematics. Despite these challenges, a current initiative recognised by New Zealand's Ministry of Education as having a significant positive impact on student learning is the *Pasifika Success Project in Mathematics*. This initiative draws on the PEP's strategy and aims to develop teachers' pedagogical actions and culturally responsive practices while supporting them to construct an inquiry-based mathematics classroom. The purpose of this paper is to outline how two teachers from the Pasifika Success Project drew on the cultural backgrounds of their students to enhance their mathematical practices. The focus of the paper is on the teachers' actions that led to their students developing adaptive skills during collaborative problem-solving activity.

Background Research

Creating high quality learning environments enables students to engage in mathematical learning. Guiding students to develop adaptive expertise in such

environments is essential to give students the opportunity to construct mathematical knowledge. The construct of *adaptive expertise* was introduced by Hatano (1982) where he initially related the notion to adaptive adults in the workplace. However, more recent research involves student learning in mathematics education. Hatano (2003) argues that a pressing issue in mathematics education is how students can learn so they develop adaptive expertise. He describes adaptive expertise as the ability to flexibly and creatively apply meaningfully learned procedures where learners explore a range of possibilities and try to make sense of their actions. Hatano (2003) compares this term to routine expertise, which he defines as being able to carry-out mathematics exercises quickly and accurately with limited understanding. He argues that if an educational environment is oriented toward solving a set of problems, students will become experts defined in relation to accuracy and speed (routine experts). In contrast, when learning environments meet varied demands, students are able to develop adaptive and flexible skills therefore developing adaptive expertise.

Similarities can be drawn from Hatano's (2003) routine and adaptive expertise constructs to Boaler's (2006) notion of multi-dimensional and uni-dimensional classrooms. Boaler's (2006) four-year study of an equitable approach to mathematics teaching and learning illustrated how the multi-dimensionality of classrooms contributed to high student achievement. Boaler (2006) describes a uni-dimensional classroom as a classroom where only one dimension of mathematical work is valued and to be a successful mathematician students have to execute procedures correctly. Boaler (2006) advocates for heterogeneous groupings in multi-dimensional classrooms where many dimensions of mathematical work are valued such as asking good questions, mathematically explaining ideas, and justifying solution strategies. Hatano (2003) shares a similar view. He argues that through questioning, conceptual knowledge that is related to a procedure can be developed. This can occur through discourse and students asking why each step is needed during its application. Hatano (2003) notes that this process is similar to Schoen's (1983) notion of *reflection in action*. The similarity being that both researchers argue that knowledge is constructed through the process of solving problems.

Developing an understanding of mathematical concepts through exploration is supported by research on developing adaptive expertise in mathematics. For example, Markovits and Sowder (1994) designed a three-month unit that focused on providing opportunities for students to explore the relationships between numbers and a range of operations. Rather than introducing new procedures, this was aimed at encouraging the development of a deeper conceptual understanding of the content they had already acquired. Following the intervention, students from the experimental group were compared to students taught with a traditional curriculum. The results indicated that the students in the experimental group had greater number-sense. These researchers concluded that the exploration of the relationships between numbers and differing operations aided the students in solving novel problems. Similarly, Mercier and Higgins (2013) associate the development of adaptive expertise with the opportunity for students to be innovative and exploratory with mathematical concepts. This includes exposure to multiple solution strategies. By allowing students to explore and reflect upon the different solution strategies, these researchers contend that each student will choose a strategy that is "personal and insightful" supporting them to become more flexible and adaptive.

Participation in collaborative discussions can be a powerful way for students to develop adaptive expertise within mathematics. Staples and Colonis (2007) differentiate between two types of discussions: sharing and collaborative discussions. In sharing

discussions, they note that students are urged to understand others' ideas however they maintain a connection to their own ideas. In contrast, these researchers define collaborative discussions as extending beyond understanding others' ideas to responding to, extending, or connecting to the ideas to form a new perspective. Similarly, Chapin and O'Connor (2007) advocate the use of talk moves by teachers to engage students in academically productive talk. These talk moves include *revoicing*, *repeating*, *reasoning*, *adding on*, and *teacher wait time*. Use of these can promote collaborative and equitable discourse hereby contributing to the development of adaptive expertise.

The development of productive discourse during collaborative discussion requires a suitable classroom environment. To achieve this, Yackel and Cobb (1996) propose the use of socio-mathematical norms: social norms that are unique to mathematics. Such norms describe appropriate mathematical discourse and engage students in mathematical practices such as mathematical explanations and argumentation. In Yackel and Cobb's (1996) study, they explored the development of norms in inquiry-based mathematics classrooms. A key finding of this study was that when teachers set up socio-mathematical norms, students developed flexibility and sophistication in their use of mathematical constructs, key aspects of adaptive expertise.

Also of importance to this study is the notion of culturally responsive practice. Drawing on students' cultural backgrounds facilitates student engagement in learning mathematics. Hawk, Cowley, Hill, and Sutherland (2005) urge educators to attend to the cultural well being of Pasifika students by building on their cultural capital. An example of the importance of this is found in the study by Averill and Clark (2012). This study focused on high school students' perceptions towards the cultural value of respect. These researchers found that students believed teachers were respectful if they held high expectations and believed in their students' abilities. This included giving students time to think and problem-solve during mathematics rather than explaining a solution directly to students. Similarly, Hunter and Anthony (2011) found in their study that the case teacher drew on his students' concepts of respect and reciprocity to encourage students to actively listen, question, and support each other during the learning of mathematics. This led to positive outcomes for the Pasifika students as they were positioned to engage in inquiry discourse and develop collective mathematical practices.

The theoretical framework of this study draws on a socio-cultural perspective. This perspective views students' mathematical activity as a social process that develops as students participate in mathematical practices (Yackel & Cobb, 1996). Hatano and Oura (2003) observed in their studies that gaining adaptive expertise occurred in socio-cultural contexts. These contexts are related to student interests, values, and identity where learning is socially significant, such as solving real-world problems. Extending this socio-cultural perspective is Lave's (1996) emphasis on the community as opposed to the individual. Lave (1996) states that mathematics should not be viewed as an abstract task or individual practice but an activity that is deeply bound in social activities within a community. Learning can therefore be viewed as occurring through participation in practices and the gradual attainment of expertise which contributes to the development of children's mathematical identities.

Methodology

This paper reports on a case study of two classrooms drawn from the wider Pasifika Success Project. The case study design was used to gain an in-depth understanding of factors that contributed to Pasifika learners developing adaptive expertise in inquiry-based

mathematics classrooms. The research took place in November towards the end of the school year, which coincided with the near completion of the PLD project for teachers. Participants were students from two New Zealand urban primary schools, aged ten to thirteen years old, of Pacific Nations ethnicity. These students came from low socio-economic home environments and many spoke English as their second language.

Data collection involved semi-structured focus group interviews and video-recorded footage of mathematics lessons. Field notes were used to support the classroom observations. The interview and video-recordings were wholly transcribed and, through an iterative process using a grounded approach, patterns and themes were identified. Five key themes related to cultural values emerged from the analysis of the data: respect, reciprocity, service, inclusion, and leadership.

Results and Discussion

In this section the five key themes that were identified from the data analysis will be discussed in reference to the teachers' actions that drew on their students' cultural backgrounds. These actions that presented students with the opportunity to develop adaptive expertise involved developing collaboration within groups; promoting collaborative discourse; and fostering inclusion and adaptive skills through using mathematical practices.

Developing Collaboration within Groups

Both teachers deliberately set up their classroom learning environments with a focus on an exploratory approach to mathematics learning: students were encouraged to explore and be innovative with mathematics concepts. To support this, students were presented with cognitively demanding group-worthy problems and the expectation was that they would collaboratively explore the problem and engage in sense making. These actions drew on the cultural value of respect: teachers showing respect for their students' abilities to construct knowledge while problem solving (Averill & Clark, 2012). Within their planning the teachers identified key mathematical ideas to which student learning was connected to during the conclusion of the lesson. The structure of this learning environment ensured opportunities for students to think creatively and collaboratively generate multiple solution strategies to mathematical tasks.

Purposeful grouping of students was used to set up a learning environment that promoted mathematical practices and drew on cultural values. The social and grouping arrangements of the students consisted of a heterogeneous make-up (varying attainment levels) with groupings of three or four students. The teachers purposefully assigned students their groups based on social and mathematical skills and changed these groups on a daily basis. This required students to develop their ability to work with different students. When questioned about this grouping arrangement, students showed a consensus in favour of this approach and responded with the following comments:

Laisa: We work with different people all the time, doing different roles. We now like working with anyone in our class.

Mere: People can have different skills and think differently from you. That's a good thing. You can learn new things from them.

Laisa: In same ability groups you don't learn much because you are all the same.

As evidenced in the comments from the students, they valued the opportunity to work in heterogeneous groupings with different members of the classroom community.

In order to promote equitable participation the teachers refrained from assigning students to roles within the group. Instead students were given the flexibility to take turns at different roles at their own discretion. This also countered academic and status differences within the groups (Boaler, 2006). However, working in this way necessitated that students adapted to carrying out a multitude of roles within a group. This was recognised by the students:

- Tania: We have learnt more skills by doing different roles.
- Laisa: Everyone has something to contribute to the group - strategies, questions, explaining differently.
- Mere: We don't have one leader - leaders always change. We see ourselves as learning from each other.

The classroom environments drew on the cultural backgrounds of the students. Within the comments from the students links were made to the cultural values of inclusion, leadership, and reciprocity. For example, inclusion is depicted by the need for equitable participation as noted by the students. They emphasised that all group members have skills to contribute to group work and that students carry out different roles. Mere made reference to leadership as a shared role where students take turns leading their group; this may be enacted by constructing and explaining part of a solution to group members. Reciprocity was illustrated by the students' view of themselves as learning from one another and Laisa noting that every group member has important mathematical skills to contribute during group work.

Promoting Collaborative Discussions

The development of collaborative discussions was a key element of these classrooms. The case teachers used specific talk moves to promote collaborative discourse among group members. During the small group phase of the lesson, the teachers monitored the group activity and the students' participatory actions. When the teachers noticed limited use of mathematical practices, they responded by asking certain students to explain their reasoning and for other group members to ask questions, repeat an explanation in their own words, agree or disagree with a reason, or add on to the group's idea.

The collaborative grouping structures described in the earlier section and development of specific norms enabled students to develop their own discourse to support one another during collaboration. For example, in one lesson the different group members engaged in collaborative discourse to contribute towards the development of the group's solution strategy.

- Sefu: So it's twelve point six five kilometres plus five point seven eight kilometres equals ... what's a strategy we can use? We can do different strategies.
- Lenni: What about partition a number?
- David: Twelve point six o plus zero point zero five.
- Lenni: Then that one is five point seven o plus
- Sefu: Zero point zero eight.
- Lenni: So what do we do now? Add the tenths then hundredths numbers together.
- David: 60 plus 70?

Lenni: 130. But remember it will actually be one point three zero not one hundred and thirty because there's a decimal point in the middle.

In this discussion the students collaboratively developed a solution strategy along with constructing place value knowledge as Lenni reasons with his group members about the correct terminology associated with the concept.

Students also identified the importance of collaboration while engaging in discourse to develop solution strategies during the focus group interviews:

Laisa: When people feed off each other's ideas it becomes deeper thinking. We find that we come up with new things that we didn't think about.

Tina: It's important to be ready for mind change - when you are used to doing one strategy and you see another person using a new strategy you can connect to that and learn it.

These responses draw on the value of co-constructing solution strategies together by building on and extending one another's ideas (Staples & Colonis, 2007). This involves making sense of different ideas and synthesising the ideas to develop new knowledge.

Furthermore, value was also placed on inclusion of others during collaborative activity in mathematics lessons:

Sally: It's about sharing your knowledge with your group members.

Kali: If someone hasn't got it we spend time practising and going over a problem, helping each other and our solutions before presenting.

Fia: We don't just think about ourselves - we help others to get on-track.

Sally: So no one is left out. So we know that everyone is learning.

Tini: We feel more successful if our whole group gets it.

However the students also recognised that they needed to use specific strategies to ensure that they supported each other within their group discourse. Interestingly, these paralleled some of the talk moves outlined by Chapin & O'Connor (2007) that were used by their teachers:

Kali: We say can you add on? Can you paraphrase, to see if the audience is still following us?

Tini: Do you agree? Do you disagree? Can you explain and justify your strategy? Does anyone have another strategy?

It is evident that Kali and Tini developed adaptive expertise from participating in collaborative activity. These students adopted the talk moves used by their teacher and adapted these to support each other during collaborative discussions. The talk moves supported students in exploring various concepts in mathematics and encouraged them to make sense of their actions: this is viewed by Hatano (2003) as adaptive expertise.

Again links can be made to Pasifika values when examining both the students' comments and interaction from the classroom. In particular, reference was made to the value of service in relation to the importance of serving group members so everyone in the group experiences success (Boaler, 2006). Additionally other comments referred to by these students strongly value inclusion to ensure no one is left out and all group members learn.

Fostering Inclusion and Adaptive Skills through using Mathematical Practices

In both classrooms, the teachers led the development of socio-mathematical norms during mathematics. These included providing mathematical explanations, using different

representations, and justifying solution strategies using mathematical reasoning (Yackel & Cobb, 1996). Through emphasising the social and socio-mathematical elements of the classrooms, learning environments which valued many dimensions of mathematical work were developed (Boaler, 2006). This was evident when students were asked to describe how they worked during mathematics.

- Laisa: We ask a lot of questions - about what we don't understand about the problem. We paraphrase - people have to explain in their own words.
- Tania: We stop and check on each other to see if we understand or agree. Do they agree with the answer or the strategy we used?
- Mere: They have to justify their answer and why they disagree. They have to try and convince us.
- Tina: We make sure everyone's on-board. We paraphrase and add on. If we have different answers we justify until we come to an agreement. We have to make sure everyone has got it.
- Laisa: We use pen and paper and write or draw whatever we like to help each other.
- Mere: If you are asking questions you are getting a better understanding of what you're doing. Also, if you paraphrase you are getting a better understanding of what the problem is about so you're building your knowledge and get deeper thinking.

Again, within the descriptions from the students, the links to Pasifika values such as service and inclusion are evident. The students emphasise the importance of ensuring all group members understand by enacting many important dimensions of mathematical work, including questioning, using different representations and justification (Boaler, 2000). Engaging in these practices while solving problems enables students to construct their own knowledge and develop adaptive expertise (Hatano, 2003).

Conclusion and Implications

The findings of this study indicate that students are able to develop adaptive and flexible skills when teachers set up appropriate learning environments that promote adaptive expertise. Key to this is the use of an exploratory approach to problem solving that gives students the opportunities to create multiple strategies and engage in mathematical practices (Mercier & Higgins, 2013). Pasifika students were given the opportunity to think creatively and construct their own knowledge that exemplifies the value of respect. Similar to what Averill and Clark (2012) described, the teachers showed respect for their students' abilities.

Heterogeneous grouping was also used to promote adaptive expertise. The regular mixing of groups contributed to the students' developing adaptive skills to be able to work with different students and carry out different group roles. Also linked to this were connections to cultural values such as reciprocity, inclusion, and leadership. This is similar to Boaler's (2006) findings that highlighted the value of reciprocal learning when students were placed in heterogeneous grouping.

By carefully structuring collaborative discourse, teachers were able to promote the values of reciprocity and service. Collaborative discussions enabled students to build on to one another's ideas when co-constructing a solution strategy (Colonis & Staples, 2007). Students demonstrated service by supporting each other to understand group solutions while engaging in mathematical practices. During small group discussions, students also displayed adaptive expertise by generating their own talk moves. Placing an emphasis on socio-mathematical norms encouraged students to use and value different dimensions of

mathematical work; this included mathematical explanations and justification (Yackel & Cobb, 1996). Lastly, the findings reflect Hatano's (2003) perspective of knowledge construction, when students are given the opportunity to solve problems in a learning environment with varied demands, students are able to construct knowledge and develop adaptive expertise.

This study presents a culturally responsive approach to the teaching of mathematics that produces positive outcomes for Pasifika learners. In this study, students were positioned as adaptive co-constructors of knowledge. If educators are able to view students as knowledge creators who develop adaptive skills during mathematics learning, this may counter deficit beliefs towards students' abilities. A key finding is that when learning environments and teachers' pedagogical actions draw on students' cultural backgrounds, learners can develop adaptive skills that support them in using mathematical practices. This study adds to the existing research base on culturally responsive teaching for Pasifika learners by analysing Pasifika values and how they can be related to mathematics learning in specifically designed classrooms.

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