Making Mathematics Accessible for All: A Classroom Inquiry

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Patterns of participation in mathematics are often affected by power and status structures in the classroom. This case study focuses on two 10-year-old students who have achievement and status and power issues in mathematics, within a class of predominantly Maori and Pasifika students from low socio-economic backgrounds. The findings illustrate the impact teachers have on the opportunities to participate available to students in the mathematics classroom, through practices which explicitly address status issues. Importantly, they show that unless teachers intervene to address inequities and promote participation the status quo of diverse students underachieving in mathematics remains.

Mathematics is a social endeavour and therefore a key component of mathematical inquiry learning is active participation of students in the classroom community. There is considerable research evidence which emphasises the positive relationship between student participation and their achievement in mathematics (e.g., Anthony & Walshaw, 2007; Barnes, 2005; Ing et al., 2015). However, for some students accessing the mathematical discourse holds its own challenges, and therefore examination of the nature of patterns of participation to ensure equitable access to mathematical learning is a critical issue in classrooms (Barnes, 2003; Barnes, 2005; Bennett, 2014; Civil, 2014; Lack, Swars, & Meyers, 2014; Rubel, 2017).

One aspect which needs consideration are the power and status structures which exist in the classroom and which shape participation in both positive and negative ways (Civil, 2014). The focus of this paper is on two students who currently have achievement challenges in mathematics. The aim is to examine each student's participatory practices, evaluate their learning opportunities, and investigate the factors that promote or inhibit opportunities to learn. These include, for example, rich tasks that build mathematical understandings, participation in group work, and opportunities to communicate mathematical thinking.

The specific research questions explored in this paper are:

- What factors in the learning environment inhibit or enhance student's participation in a mathematical inquiry community?
- What actions can teachers take to proactively and consistently promote equitable patterns of participation in the classroom?

Literature Review

In the past two decades attention has focused increasingly on the role of participation as a way to gain equitable outcomes in mathematics. One particular focus has been placed on the role power relations and status hold, in who gets to participate in positive ways in mathematics classrooms. Civil (2014) links equity, power and status relationships in mathematics classrooms to participation. These power and status structures, present within wider society, play out in many different ways in classrooms often linked to race, ethnicity, gender, socioeconomic status, and even personal popularity. They not only influence who

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gets to participate in mathematical discussions but also how contributions are valued. Different contributions may be ranked according to an expectation of competence tied to an allotted status. Lack and colleagues (2014) illustrated the ways in which status perceptions influence student interactions. In their study, they found that high status students dominated classroom discussions, working on the assumption that their contributions were most valid.

The social construction of race and white spaces is another significant element of equity discussions in mathematics education (Rubel, 2017). Rubel argues that race is pivotal in perpetuating societal inequities and widening gaps in mathematics opportunities and outcomes. She advocates teaching mathematics for social justice through teachers explicitly exploring the dominant role of "whiteness" in the mathematics classroom and developing equity-directed instructional practices (p.66). For example, through culturally relevant pedagogy teachers connect mathematics instruction to students' cultural practices, out of school experiences, and real lives, rather than just reflecting and valuing the typically white, middle-class cultural practices of schools (Rubel, 2017).

Many teachers assume that students are able to work collaboratively in small groups. However, many studies (e.g., Barnes, 2003, 2005; Hunter, 2007) show the negative impact on some students when teachers do not specifically attend to how students participate in the discourse. For example, Barnes (2003) illustrated the power relationships which evolved when she identified the social positions that the students either took or had assigned to them by others. She describes the position of "outsider" – students who are frequently ignored and treated as though they do not have the same rights as others to contribute to discussions. For these students being positioned as "outsiders", resulted in them having little power, and few opportunities to make productive contributions. This showed that the approval of an idea had less to do with its usefulness or correctness than with who proposed or who supported it.

Teachers hold an important role in ensuring high-quality, equitable participation for all students in the mathematical discourse. Bennett (2014) suggests a number of pedagogical strategies teachers can use to build strong classroom culture based on equitable access for all to participate. Creating classrooms that focus on reasoning, deep conceptual understanding, and communication of mathematical thinking are key factors because student understanding of what mathematics is, and their self-perception as a learner of mathematics, powerfully influences their participation (Ministry of Education, 2009) and their identity as a mathematical learner. But also, the classroom norms need to convey an expectation of active participation from all students. Civil (2014) identifies cultural responsiveness as also important in the mathematics classroom. She argues that when this is considered students are encouraged to participate, contribute and have opportunities to learn. However, teachers also need to monitor and actively work to resolve status and positioning as students interact in large and small groups. Civil (2014) provides one strategy to address status through assigning competence. Barnes (2005) explains that through drawing attention to and praising good ideas or solutions as an example of assigning competence the teacher is able to gradually increase recognition from the class that all students have something of value to contribute. Other factors of importance include the use of heterogeneous grouping structures and rich tasks which reflect students' experiences and knowledge, and require multiple abilities to solve (Civil, 2014; Lack et al., 2014). These give every student opportunities to participate and illustrate that there are different ways to be "smart" in maths, which challenge student perceptions of what it means to be "good" at mathematics (Civil, 2014).

Teachers also need to interrogate their own beliefs about status and their role in facilitating the talk. Importantly teachers need to ensure that they do not fold back to traditional teacher-driven discussion, labelled by Barnes as a "teacher helping pupil storyline" (2003, p.2). The teacher's role is to contribute to the discussion through probing student thinking, asking and supporting students to ask clarifying questions or helping guide students in their reasoning (Bennett, 2014). This positions teachers as the pedagogical experts, rather than the intellectual authority, within the classroom (Bennett, 2014).

The theoretical framework underpinning this study is a socio-constructive view of learning mathematics. Learning is viewed as a fundamentally social activity, where students make sense of mathematics through active participation (Perry, Geoghegan, Owens, & Howe, 1995). Using this framework supports focusing on the mathematical learning students construct through participating in the classroom community and provides insight into the role of the teacher in classrooms where students collaboratively create mathematical understandings (Perry et al., 1995).

Methodology

This small-scale study was conducted at an urban, New Zealand, primary school with predominantly Maori and Pasifika students from low socio-economic home environments. The study was conducted over four weeks and is based on a series of three classroom observations. A qualitative, case study approach was used to gather data to answer the research questions. The data collected were recorded observations of classroom lessons, field notes, and interviews involving a series of open ended questions with the two students. Analysis of the data consisted of determining themes based on evidence of participation in the classroom, and teacher actions which facilitated or precluded this.

Two Year 8 students were selected for the study, based on their teacher Sarah identifying them as struggling to achieve in mathematics. The first student, Huia, is of Maori descent and the second student, Meilani, is of Cook Islands descent. Both girls are actively involved in their cultures, particularly through kapa haka, drumming and dance. Huia and Meilani are puzzles of practice for Sarah because both students are achieving at or above national standards in all other subjects but are below national standards in maths.

Results and Discussion

Perceptions of Mathematics and Doers and Users of Mathematics

On interview, both Huia and Meilani stated that they did not like mathematics.

> Huia: Maths is just about adding numbers in different ways. I don't like maths. It's hard learning new strategies.
>
> Meilani: Maths is ok but I don't really like it. I like doing times tables but I'd be better at maths if I knew more divided bys. You need to practise things like times tables and know how to work things out.

Clearly, their explanations for not liking mathematics centred on their perception of mathematics as facts and strategies to be learnt rather than making connections to the concepts and relationships within mathematics. Some of their antipathy towards mathematics could be attributed to the problems used in the observed classroom which appeared to focus on procedures and correct answers, rather than exploring and understanding mathematical concepts and relationships. For example:

> There are 72 ice creams in the freezer. Two eighths of them are eaten by Huia and her friends. Five eighths are eaten by Meilani and her friends. How many are left over?

While the teacher has included Meilani and Huia's names in the problem, it does not take the cultural diversity of them into consideration. This resulted in Huia when asked how it felt to be Maori in maths stating:

> It's English maths about English things.

Huia provides evidence of the teacher's implicit positioning of her own cultural values and practices as the norm. To connect mathematics to students' realities teachers need to learn about their student's heritage, home languages, interests, everyday activities, and out of school lives, and develop strategies to effectively teach students who have cultural backgrounds and experiences which differ from their own (Rubel, 2017). The tasks students engage with not only determine the mathematics they learn, but how they come to think about, develop, use, and make sense of mathematics (Anthony & Walshaw, 2009). Situating mathematics tasks in students' cultural contexts empowers them to participate through considering mathematics as part of their own identities and lives (Anthony & Walshaw, Rubel.

How students also see themselves as learners in the mathematics classroom and how this affects their status and positioning is influenced by how students are grouped. The teacher stated that she used flexible grouping, but in reality, she split the class into those working at Level 2 - 3 of the Curriculum, and those working at Level 3 – 4. Her justification was so that "children with similar abilities could work together". This meant that students were positioned and taught according to the teacher's perception of their mathematical ability. For example, as students worked on a problem about whose family had eaten more pizza; either the family who ate 6/8 of their pizza or the family who ate 7/10 of their pizza. The teacher acted in different ways as she engaged with the different groups. When she went to Meilani's group she explicitly intervened and asked leading questions which allowed them no opportunities to explore solutions or contribute a range of ideas. For example, she asked:

> What would be easier to compare than eighths and tenths, how could you find something the pizzas have in common?

Through such actions the cognitive demands were lowered and those students the teacher considered were lower in ability were provided with less opportunity to participate in higher order thinking.

The students knew they were placed in lower ability groups and this also affected their attitudes to mathematics. For example, Huia stated:

> Other people know and other people understand maths but I don't. You feel like their ideas are better than yours.

Her statement illustrates her awareness of who the "smart" students were and where they stood in the classroom hierarchy in terms of who got to talk and whose contributions were valued in both group and class discussions. Huia saw herself as an "other".

While small group discussions can provide opportunities for students to extend their thinking, poor communication within groups limits participation and engagement with the task. Observations provided evidence that most groups in the class used cumulative talk, where everyone uncritically accepted and agreed with what other people said, rather than doing what Mercer (2008) describes as necessary in constructive mathematical discourse

where ideas are challenged in the process of constructing knowledge. The students also need to actively participate in meaningful discourse through engaging in mathematical practices (Bennett, 2014). In all three observations both Meilani and Huia's groups drew diagrams showing fractions of a whole, but the representations were not connected to any reasoning. Meilani and Huia appeared uncertain about how to participate in such practices as justifying, arguing, and generalising. However, they were given no support or scaffolds to learn these skills.

Questioning

Teacher questioning to support students to engage and participate in mathematical discourse also acts as important scaffolds for students to access deep and rich reasoning. Teachers frequently ask students open-ended questions after they have solved a problem, for example, "how you solved the problem?", and can draw out an initial student explanation. However, teachers find it more difficult to follow up on student ideas and ask questions that support students to participate in making their thinking explicit or understanding other students' strategies (Franke et al., 2009).

The observations illustrated a pattern the teacher took when groups explained how they solved the problem. The teacher would intervene and ask questions such as:

> Are you following that? Do you agree with that?

However, when receiving a yes or no response from the students she did not press for clarity or expect that the students would justify their reasoning. Thus, the discussions held little evidence of the students collaboratively constructing mathematical ideas or developing new perspectives and understandings. This also limited Huia and Meilani's access to broaden understandings and make rich connections across different student's reasoning.

Status and Positioning of Learners

On interview Meilani and Huia both stated that people in their class treated each other with respect "sometimes", and they both stated that the "popular people" bullied others. These statements illustrate the way they perceived themselves in contrast to others and affected their participation and contributions to the mathematical discourse.

When asked "Who's good at maths in your class?" Meilani and Huia both named the same students.

> Huia: The teacher thinks they're good at maths too. They're usually chosen to explain their ideas and they can talk about their ideas.

Clearly, the students perceived as holding low status were generally expected to be less competent. This allowed them to take a passive role where they did not need to question or contribute unless responding to the teacher's closed questions. Observations showed that Huia's body language consistently conveyed her own perception of her low status or "otherness". She usually sat looking at the ground and seemed like she wanted to disappear. This was further reinforced by the teacher who in one classroom observation initially asked Huia to explain her thinking. However, when she felt Huia was taking too long she took the paper and said:

> Sorry Huia we're running out of time so maybe we'll come back to this. Lei can you explain how you solved the problem please?

Lei, one of the students considered "good at maths", then showed how to multiply the two denominators to find a common denominator. Children watch and interpret teacher's actions to see what they value. The teacher's actions in this instance conveyed a clear message that Huia's input was of less value than that of others in the group.

Barnes (2003) describes some students as "attention-avoiders". During the observations Meilani appeared interested and often took up a position as a helper, for example, writing everyone's names or asking questions, but not a position where she would influence others through sharing her own thinking or reasoning about a problem. During one observation the teacher asked Praise, a member of Meilani's group with high status, to explain. While Praise was talking Meilani was speaking quietly to Chontel who was sitting next to her.

> 8 represents 2/8 and ⅝ with one group left over. You could draw ⅞ 'cos ⅜ plus 4/8 is ⅞.

While it was clear that Meilani was engaging with the reasoning she was reluctant to share her thinking with the larger group. A role the teacher needed to do in this instance would be to publically notice and respond to Meilani's whispered comments. Through such means the teacher could give Meilani more confidence in her voice and position her as someone competent in mathematics with strengths, abilities, and valid ideas to contribute.

Conclusion and Implications

Meilani and Huia both face barriers to participating in mathematics and this had resulted in them having a negative disposition towards mathematics, a sense of "otherness" and passive participation which had resulted in lowered achievement. As Barnes (2005) illustrated students who participate less, learn less.

The teacher role is significant in creating patterns of participation in the mathematics classroom. To promote equal status interactions and participation amongst students requires teacher intervention (Barnes, 2005; Civil, 2014). Unless teachers intervene to equalise rates of participation, "'the rich get richer,' and the gap in academic achievement widens" (Cohen, Lotan, Scarloss, & Arellano, 1999 as cited in Civil, 2014, p.7). As Anthony and Walshaw (2009) explain the teacher's actions directly affects what is happening and for who. In the case of Meilani and Huia unless there is effective teacher intervention, in line with Lack and colleagues (2014) propose, these two students are positioned in ways that cause them to have less opportunities to participate and therefore achieve.

One action which is important given that mathematics is a social endeavour would be the need for the teacher needs to address status issues. The social construction of mathematical learning takes time and patience, however, creating a strong culture of participation is imperative for developing all students as capable and confident mathematicians with a deep understanding of mathematics (Bennett, 2014; Lack et al., 2014). Bennett (2014) argues that key actions include active support for collaboration, and the building of a caring, inclusive and a respectful learning community. To give Meilani and Huia the best opportunities to participate the use of ability grouping needs to be addressed. As Civil (2014) proposes grouping students needs to focus on their different strengths and ways of thinking within heterogeneous groups where groupworthy problems tasks that incorporate students' cultural identities are used which draw on multiple competencies. This supports students to have multiple ways to learn from each other

(Anthony & Walshaw, 2009) and also would support Meilani and Huia to connect school mathematics with the mathematics they use in other parts of their lives.

In such a setting the culture of participation will promote productive mathematical discourse, and Sarah can make this meaningful and rich by expecting and supporting all students to participate in mathematical practices and communicate their explanations, justification, and argumentation (Bennett, 2014).

The implication we need to consider is the reality that there is far more to participation issues than students being shy or reluctant to share their thinking. Participation in a mathematical inquiry community is about how the teacher establishes and maintains the classroom as a safe and equitable learning environment where every student develops a positive mathematical disposition, can see the value of mathematics in their work, actively participates in learning mathematics, and believes they can succeed.

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