Examining Nondominant Student and Teacher Agency in a U.S. High School Mathematics Classroom

Rachel Restani
Massey University
<r.restani@massey.ac.nz>

Shifting classrooms towards places where students' ideas are at the centre of the discussions has been challenging for teachers to put into practice (Hiebert & Wearne, 2003). This study explores the attempts I made as a researcher-teacher to promote equitable student-driven whole class discussions in a racially and socioeconomically diverse classroom. Using ethnographic methods, I examined the research question: *What are the successes and challenges a teacher encounters when attempting to promote student agency in an Integrated Mathematics 1 classroom?* I used one transcript from the end of the year to illustrate examples of student and teacher participation and areas for improvement.

Existing mathematics classroom practices currently perpetuate global social inequities (Apple, 1995) by privileging ideas and dominant ways of being from Eurocentric groups of people (Lipka, 1994). This limits the number of students who are successful under traditional instructional models (Tate, 1997). Mathematics classrooms tend to prioritize rote practice of procedural skills over critical thinking or conceptual understanding (Hiebert & Wearne, 2003). In the U.S., students in low-SES communities or in urban areas receive less exposure to problem-based lessons or whole class discussions than their more affluent counterparts (Lubienski, 2000). Yet many STEM education practitioners and researchers have argued that reform-based practices, such as student exploration of procedural and conceptual ideas, can strengthen learners' mathematical understandings (e.g. Moschkovich, 1999; Stein, Grover, & Henningsen, 1996). The recent Common Core Standards in the U.S. state that all learners should speak about mathematics in ways that students believe are meaningful and rigorous (Yonezawa, 2015).

Asking students to explain what they know can strengthen mathematical conceptions for all participants in the classroom (Kazemi & Stipek, 2001). This constant press to justify one's thinking is most effective when it becomes part of the normative expectation of the classroom practice (Yackel & Cobb, 1996). Sociocultural practices, such as whole class discussions and small group collaboration, require a slow release of scaffolds as students learn how to take responsibility for their own learning processes (Hufferd-Ackles, Fuson, & Sherin, 2004). This is especially important for students who have been marginalized from traditional mathematics who may lack the confidence and skills required for verbal participation (Ball, 1993; Planas, & Gregorió, 2004). I use the term marginalised synonymously with nondominant or underserved to describe any person outside of the dominant norm regarding race, class, gender, language, ability, sexuality, educational background, and other underserved groups.

In this paper I support student-centred discussions of ideas, finding that instructional practices that empower students through responsive instruction is possible within an integrated high school mathematics classroom. Drawing on a teacher action research project that I implemented as a researcher-teacher (Ball, 1993) in two Integrated Mathematics 1 classes, I describe how the classroom community can make student agency a tool for learning, while also attending to the challenges that prevent some teachers from

shifting mathematics education towards student-centred spaces where students can critically engage with mathematical ideas.

Relevant Literature

Sociocultural Learning Theory

In recent years there have been a growing number of research studies where scholars have touched upon the ways sociocultural learning practices can support mathematical understanding. I build off Vygotsky's (1978) sociocultural learning theory, claiming that one constructs individual ideas after interacting with others, to examine the ways whole class discussions support learners' development. Mathematics educators have pushed for a balance between procedural and conceptual fluency by urging practitioners to press students to discover multiple solution strategies (Stein et al., 1996) and explain their thinking regarding those methods (Kazemi & Stipek, 2001). Discussion over students' ideas occurs most organically during open-ended problems where there are multiple entry points into the problem (Boaler, 1998). An interactive environment requires the teacher to become a facilitator of the discussion rather than a transmitter of information (Truxaw & DeFranco, 2008).

I define equitable whole class discussions as places where all students are free to express mathematical ideas, not just those who have traditionally been successful in mathematics. This study draws on the work of Cohen and colleagues (1999) in relation to the idea of eliminating status so that all learners feel comfortable sharing their mathematical ideas out loud, regardless of traditional positions of power. Additionally, the work of Hufferd-Ackles and colleagues' (2004) is drawn upon, with the idea of a math-talk learning community which stresses the importance of utilising students' mathematical ideas to guide discussions. Whole class discussions are effective when all learners have opportunities to share their mathematical ideas, not just those who are fluent in the language of instruction or those who score high on achievement tests (Ball, 1993; Planas, & Gregorió, 2004).

Agency

Classrooms that promote student interactions allow more opportunities for students to have agency over their own learning processes. I use Turner's definition of mathematical agency: students who construct rigorous mathematical understandings and who participate in mathematics in personally and socially meaningful ways (Turner, 2003). Holland and colleagues (2008) refer to the different ways people take up roles in various situations as the agency they have in each of their Figured Worlds. They explain that from one context to the next, people choose to act in certain ways depending on how they identify with those situations. Thus, the behaviours students choose to engage in fluctuates depending on how personally and socially meaningful the structures (tasks, norms, activities) are in the classroom. Dialectically, the structures also change depending on how participants choose to interact (Varelas, Tucker-Raymond, & Richards, 2015).

Because of this fluidity, I acknowledge Solórzano and Solórzano's (1995) contribution, that human agency is the confidence and skills to act on one's own behalf. Therefore, learners who lack confidence in their mathematical abilities may be less inclined to contribute to whole class discussions in mathematically meaningful ways. This is especially true for groups of people who have traditionally been marginalized from

mathematics. Hence, I rely on Yackel and Cobb's (1996) distinction between social and mathematical norms to separate when participants contributed to the social expectations of the classroom and when learners expressed rigorous understandings of the mathematical material.

Methods

This study explored the ways students from a diverse range of ethnic and socioeconomic backgrounds contributed to the whole class discussions by focusing on the agency employed by the students and me, the researcher-teacher. I simultaneously implemented instruction and collected artefacts in a U.S. classroom to better understand what was required to implement reform-based practices. This paper addresses findings regarding the research question, what are the successes and challenges a teacher encounters when attempting to promote student agency in an Integrated Mathematics 1 classroom? In exploring the comments from one of the transcribed audio recordings, I aim to show how these utterances 1) related to the ways students and I chose to employ agency in one of the two Integrated 1 classrooms and 2) influenced how I interacted with and facilitated lessons for my students.

Action Research

Lampert (1985), Ball (1993), and Chazan (2000) were three prominent action-researchers who focused on problem-solving discussions during an era of mathematics education reform. Each of the researchers facilitated classroom discussions around cognitively demanding problems for the purpose of deepening students' conceptual understandings. Gutstein (2003), Frankenstein (1990), and Brantlinger (2013) taught mathematics using social and political issues. Their goal was to provide a space for students to discuss and reflect on social inequalities within our global society. Lessons that develop students' critical consciousness use mathematics to examine social injustices, such as comparing proportions of liquor stores to movie theatres in different neighbourhoods.

My contribution to the field combines the two goals of deepening students' mathematical understandings and teaching for social justice. I extend Lampert, Ball and Chazan's work of deepening students' mathematical understandings by shifting my lens from the mathematical richness of the problem being discussed to examining the ways students offered up their own conjectures to a problem, as stated in the Common Core standards (Common Core, 2010). Rather than focusing on topics of discussion designed to raise students' critical consciousness, like Gutstein, Brantlinger, and Frankenstein, I expanded upon their pedagogical beliefs by choosing instructional methods that gave all students opportunities to use their voice. Overall, I believed that creating an environment where all students felt comfortable making mistakes, asking questions, and critiquing each other's reasoning (Lampert, 1990) could strengthen their mathematical understanding and simultaneously empower those who have historically been left out of traditional mathematics curriculum (Gutierréz, 2002).

Context

I was the researcher-teacher for two Integrated Mathematics 1 classes at a racially and economically diverse public high school in northern California in the United States. This paper will focus on the findings from one of these two classes. The racial demographics in the Integrated Math 1 class were: 52% Black, 29% Latino, 16% Asian/Pacific (Samoan,

Filipino and Chinese), and 3% white. Seventy-three percent of students were on free-and-reduced lunch. There was a mixture of 9th -12th grade students with a majority of ninth graders. The number of students in one period of Integrated Math 1 fluctuated around thirty-five. The upperclassmen were students who had not yet passed algebra and were required to retake the class leading to a wide distribution of skills and knowledge among students in the class.

The range of skills, ages, and racial and class backgrounds contributed to the ways students chose to engage with the social expectations of the classroom. Fifty percent of the class wrote on their mathographies that they have never felt successful in mathematics. Some students expressed that they did not feel fluent in mathematics by saying comments such as, "I need to go back to third grade. I don't know how to multiply. That's why it doesn't make sense when you're talking about writing equations," or "I just don't apply myself in this class." These perceptions of mathematical and academic status created tensions that challenged my goal to shift the classroom to an interactive learning space. The range of skills, ages, and racial and class backgrounds varied.

The district was in its second year of implementing Integrated Mathematics classes using the Carnegie Learning curriculum (Bartle, 2012). My lesson-planning process focused on preparing students for the department chapter test. I closely followed the district's pacing guide using the suggested text while supplementing some activities with tasks from the Integrated Mathematics Project (IMP) curriculum (Fendel, Resek, Alper, & Fraser, 2003), Discovering Algebra (Kamischke & Murdock, 2007) texts, or Rethinking Mathematics (Gutstein, 2006). I used problems that allowed opportunities for students to discuss their mathematical understandings in small group and whole class interactions.

Data Collection and Analysis

I collected daily audio recordings, daily lesson plans, and I wrote daily field notes for the purpose of documenting the ways students talked about mathematics. Field notes were first used to categorise themes that emerged from the data (Strauss & Corbin, 1990) and the patterns from these were used determine ten days of audio recordings to transcribe. Strategic sampling (Merriam, 2008) was used to identify three whole class discussions from the beginning, middle and end of each semester. I transcribed four more discussions from second semester where I noticed students contributing who did not usually participate. I coded these ten transcriptions to find examples of student agency – moments where students took initiative to contribute to the discussion without being required by the teacher. I use one example from the last quarter of the school year to illustrate some of the sociomathematical norms that were evident in our classroom.

Results

In this example, Martin (pseudonyms were used for all participants) stood up front and wrote his conjecture for the transformation used in *Figure 1* below. He wrote, 'the shape rotated 180 degrees.' Jasmine stood up front and recorded the names of people who participated. Tiana read the prompt from her seat. I started by standing in the back of the room:

Tiana: Describe in detail the steps you took to find a, b, c, d, e in figure A.

T: It's prime. Say prime.

Tiana: Oh, a prime, b prime, c prime, d prime, and e prime.

T: Thank you Tiana. Martin, what type of transformation do you think happened from this shape to this shape? What do you think happened?

Martin: I'm going to stick with what I said first. One hundred and eighty degree rotation, that's what happened.

T [to class]: Do you agree or disagree, 180-degree rotation?

[Audience members raised their hands]

T: Yeah. Martin, why do you think that?

Martin: It's because if you rotate it, if you have like, something to rotate, it would go exactly the opposite of this, but facing this way, I mean, not exactly, but facing this way on the other side of the graph.

T: Okay, one of our tools is transparency paper. Can you show us a 180-degree rotation? (Audio, 4/18/16).
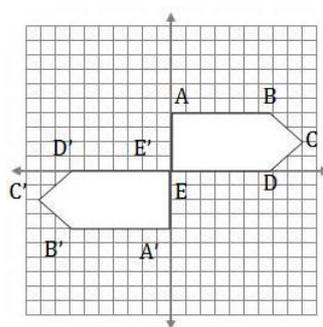

Figure 1. Picture of task during 'Transformations' discussion.

In the above transcription, Martin started the discussion by standing up in front, pointing to the graph and his written answer. After Martin explained why he believed the transformation was a 180-degree rotation, Jerry and KC joined in by sharing different conjectures with the class.

Jerry: You can reflect over the x-axis and the y-axis.

[Martin wrote, 'reflection' on the white board]

T: Reflect over the… reflect over the x-axis and the y-axis. So reflect and reflect.

[T walked up front to label the graph with arrows to visually depict what Jerry said]

Jasmine: And it's a rotation?

T: You could say either one, reflection or rotation.

Martin: So … to say it exactly, wouldn't [it] be over the y-axis?

T [used patty paper on the white board to explore Martin's understanding]: If you reflect it over the y, it would still be...

Martin: Oh! Then reflect it to the x (audio, 4/18/16).

Jasmine, Martin and I stood up front paraphrasing Jerry's idea using words, pictures and patty paper. By revoicing Jerry's input, I hoped that his ideas were valued and that the audience internalized the variety of solutions.

Last, KC offered a third description from the audience, "I was going to say it can also be a reflection over y then x" (audio, 4/18/16). I was happy to see multiple students willingly share their own ideas. KC, Jerry, and Martin took the initiative to offer their thoughts,

without waiting to be prompted by the teacher. Additionally, Jasmine's facilitation of her peers' ideas was also a way for her to play a central role in the discussion. She chose to stand up in front of the class with a marker providing a visual for the audience to pay attention to while three students spoke. Jasmine did not exhibit the confidence or skills to share her own mathematical ideas.

Discussion

Some of my goals to create an environment where students had opportunities to employ agency over their own learning processes came into fruition. As the teacher, I chose to stand on the side to prompt students to take the lead in the discussion. I positioned the audience as authorities over the knowledge by asking them to evaluate the correctness of Martin's conjecture, "do you agree or disagree, 180-degree rotation?" I also encouraged Martin to explain why he thought that transformation made sense. I purposefully chose to create an environment prioritising student sense making with the hope that students would be agents of their own learning processes. I used moves such as physical positioning and prompting to cultivate an organic discussion of mathematical ideas, similar to how mathematicians interact when determining correctness of proofs (Lampert, 1990).

Students employed agency when they volunteered their ideas without any prompting. Martin started the discussion by stating the type of transformation he thought was displayed. Jerry and KC offered two alternative transformations. Although the multiple transformations offered lacked rigor, students' contributions in the whole class discussion contained some mathematical power because the students drove the conversation (Hufferd-Ackles et al., 2004). Jasmine played an important role in the discussion by standing up in front of the class as a scribe. Although her participation did not offer mathematical insight, she chose to engage in the social expectations (Yackel & Cobb, 1996) of a student-centred classroom.

There are challenges involved when interacting in a spontaneous dialogue. After reflecting on what occurred, I realized there was more I could have done to facilitate an effective discussion of ideas. For instance, I took authority over the knowledge when I responded to Jasmine's question about multiple answers when I said, "you could say either one, reflection or rotation." In hindsight, I could have asked the audience to respond to her question. This would have created an opportunity for more students to share their thoughts in addition to the five who spoke out loud. Second, KC's statement, "I was going to say it can also be a reflection over y then x," would be more precise if KC used the terms, "x-axis" and "y-axis." Lastly, the task itself was not very cognitively demanding. This interaction would be strengthened if there was more student authority over the knowledge (Gutstein, 2003; Gutierrez, 2002), academic language (Common Core, 2010), increased cognitive demand (Stein et al., 1996) or cultural relevance (Ladson-Billings, 1995) of the task.

Conclusion

Shift Towards Student-Centred Discussions

The classroom excerpt shared above illustrates ways that I attempted to shift the Integrated Math 1 classroom from a traditional teacher-centred space to a community where students had authority over the knowledge being discussed. Some of the norms that the students and I co-created to promote discussion were evident in the transcript, such as

students up front using their ideas to guide the discussion. It was an expectation that more than one idea was discussed. As the teacher, my role was to press students to justify their ideas using complete sentences, tools (patty paper) and diagrams. My decisions were based on supporting students in purposeful ways.

Challenges

The above-mentioned challenges of implementing effective whole class discussions are real. The spontaneity of the discussion and the low cognitive demand of the task only partially matched my overall goal to encourage students to make sense of the math being discussed. The transcript is not an exemplar of an ideal situation. Rather, it exists as a demonstration of real classroom norms that were established with the goal of encouraging students' ideas to be discussed. This example can be strengthened and extended in other classrooms that share the same goal of striving to cultivate student agency.

Limitations

The evidence captured on the audio recording or written into my daily field notes limits my assessment of student agency. Paying attention only to spoken ideas does not capture the entirety of student thinking. One must remain conscious of which students feel confident and skilled enough to share their ideas out loud. My decisions and the classroom structures further marginalized some students, which limited the agency they were able to employ. With this limitation in mind, I continue to search for ways to support teachers and students to co-create classroom norms that all learners negotiate as they find productive ways to interact in their math classroom environments.

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