

Issues of Equity in a Mathematical Inquiry Classroom

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Issues of equity exist within classrooms just as they exist more broadly within society in general. This paper looks at issues of equity affecting access to learning for girls working on challenging mathematical tasks in collaborative groups with boys. It examines measures that teachers can take to mitigate inequity and foster a culture within their classroom that supports equitable learning outcomes for all students. Aspects of Engle, Langer-Osuna, and de Royston's *Influence Framework* (2014), are used to examine issues affecting access to the conversational floor, spatial orientation of group members, and the extent to which participants respond to the ideas of the female member of a collaborative group involved in mathematical inquiry. Video stimulated reflective dialog (VSRD), was employed to elicit responses and impressions from the female student regarding issues of equity that arise during group interactions. This study highlights the dynamic nature of status within heterogeneous groups, and evaluates the effectiveness of various teacher interventions in relation to equity within a mathematics classroom.

The *Developing Mathematical Inquiry Communities* (DMIC) formative intervention project facilitates teachers to develop culturally responsive and collaborative environments that effectively engage diverse learners in mathematical reasoning, leading to increasingly equitable achievement outcomes (Alton-Lee, Hunter, Sinnema, & Pulegatoa-Diggins, 2011). High value is placed on cultural diversity and the inclusion of all students in the class, with learning contexts that are drawn from the rich cultural milieu of students' lives. In such a setting, increased onus is placed on students, both in terms of the co-construction of mathematical learning, as well as the management of difficult social dynamics within groups, such as sharing their reasoning with others, agreeing, disagreeing, listening to the ideas of other group members, taking turns and collaborating towards a shared solution path. Research studies (e.g., Banks et al., 2001; Boaler, 2006; Brown & Redmond, 2016; Engle, Langer-Osuna, & McKinney de Royston, 2014; Esmonde, 2009; Franke et al., 2015, Layva, 2017) show that the complex nature of interactions within heterogeneous collaborative groups can be difficult to navigate, leading to some students being marginalised or isolated within their group, inhibiting equity of access to learning. For girls, these challenges can at times be even greater as they are faced with issues around unfair distribution of talk time, social and physical dominance of boys, and the reluctance of some boys to value or engage with the ideas of girls (Esmonde, 2009; Langer-Osuna, 2017; Leyva, 2017; Radovic, Black, Salas, & Williams, 2017).

This study will examine issues affecting equity for girls working in collaborative groups with boys and ways in which teachers can promote equity within a mathematical inquiry community, to ensure that all students have access to learning. For the purpose of clarity, this paper defines equity as "a fair distribution of opportunities to learn" (Esmonde, 2009, p.1010).

Review of Literature

While in New Zealand, statistics point to girls achieving higher levels of academic attainment in mathematics than boys (Ministry of Education, 2016), narratives of male 2018. In Hunter, J., Perger, P., & Darragh, L. (Eds.). *Making waves, opening spaces (Proceedings of the 41st annual conference of the Mathematics Education Research Group of Australasia)* pp. 455-462. Auckland: MERGA.

dominance in mathematics, and the idea that mathematics is a masculine domain still persist (Leyva, 2017; Radovic, Black, Salas, & Williams, 2017; Louie, 2017). The practice of ability grouping which is widespread in New Zealand primary schools (Anthony, Hunter, & Hunter, 2016), reinforces this masculinisation of mathematics through the implied or explicit values that this grouping practice promotes (Leyva, 2017). A learning environment that places high value on completing tasks quickly, without communication, as well as student awareness that they are artificially stratified into groups according to their perceived ability, fosters a culture of competition and exclusion within ability grouped classrooms which may be better suited to boys (Radovic et al., 2017; Louie, 2017).

Louie (2017) argues that ability grouping is a mechanism for cementing socially constructed hierarchies around gender, status, language, authority and ethnicity. Such social hierarchies exist within a classroom, just as they exist in society in general, partially because the underlying values of education systems are themselves socially constructed to reflect the values of the dominant culture (Louie, 2017). Students' attitudes and behaviours towards their peers demonstrate these socially constructed ideas and beliefs about masculinity and femininity most acutely with seven to eight year olds (Skelton et al., 2009), who constitute the focus of this study.

While the *DMIC* approach deliberately addresses inequity of learning outcomes for diverse students (Anthony et al., 2016), issues of equity still affect access to learning for some students as they work together in heterogeneous groups. This is largely because students can experience difficulties as they collaborate, communicate, share ideas and take turns with their peers (Anthony et al., 2016; Boaler, 2006). In such situations, they are required to exhibit a set of prosocial skills that enable equitable interactions within the group so that mathematical reasoning can take place (Anthony et al., 2016). However, these skills may not yet be adequately developed (Boaler, 2006). Although Walshaw (as cited in Esmonde, 2009), suggests that girls may be better suited to cooperative learning tasks, such as those found in a *DMIC* classroom, groups are not usually comprised exclusively of students of the same sex, and girls can become marginalised in a group even if there are more girls than boys (Esmonde, 2009).

Langer-Osuna (2017) suggests that access to the conversational floor can be restricted because of a "hubris penalty" (p.242), affecting who is allowed to exhibit social or intellectual authority within a group, and that girls frequently have to display more competence than boys in order for their ideas to be listened to. Girls can be prevented from participating because they are positioned by boys as low status within the group (Leyva, 2017). This restricted access to having ideas heard has implications for students working in dialogic groups, where learning is co-constructed. If, as Cohen (1998) argues, students who "talk more, learn more" (p. 19), then this points to an imbalance of equitable access to learning based on gender.

In order to effectively mitigate gender inequities in a mathematics classroom, teachers must attend to non-mathematical factors such as the equal sharing of intellectual authority, allowing equitable access to the conversational floor, the inclusion of all students, and the positioning of diverse learners as experts, in order to ensure equitable access to learning (Langer-Osuna, 2017; Brown & Redmond, 2016; Mueller, Yankelwitz, & Maher, 2011; Esmonde, 2009). To do this, teachers must be knowledgeable about students' cultural and family background, as well as their interests (Banks et al., 2001; Cohen, 1998). Teachers need to design tasks that are engaging, relevant and connected to students' experiences (Bills & Hunter, 2015). This knowledge of students' lives becomes increasingly important

for teachers wanting to ensure equity for girls who are experiencing difficulty in being listened to when working in a group. By actively positioning girls as experts, through both effective task design and specific teacher talk, teachers can publicly assign competence to individuals, calling on their cultural or experiential background to reposition them as intellectually authoritative (Cohen, 1998).

Increased equity can most effectively be accomplished by creating a classroom culture where diversity, student voice, and equity are explicitly valued above competitiveness, speed, conformity and exclusivity (Boaler, 2006). By reframing classrooms as places where equity is highly valued, teachers can promote a growing awareness for students that prosocial attributes, such as listening to others (Franke et al., 2015), showing fairness, being empathetic and compassionate, taking turns and valuing the ideas of others have positive implications not only for effective participation in a collaborative mathematics group, but also for future life as a member of a diverse society (Boaler, 2006; Louie, 2017).

Methodology

This study was conducted with students from a culturally diverse, lower socio-economic, state integrated Catholic primary school in a main centre in a suburban area. The students involved came from Niuean, Māori, Latin American and Indian cultural backgrounds. Three students were selected for this case study, one girl and two boys. Although the interactions of three students are analysed, the experiences and impressions of the female student, in terms of equity, are the main focus of this case study, with the aim of answering two key questions: What factors affect equity for girls working in collaborative mixed ability groups? And, how can teacher interventions promote equity in a mathematical inquiry community?

The study required a student to reflect on interactions within their dialogic, heterogeneous group while they worked on a culturally connected, challenging mathematical task. Video stimulated reflective dialogue (VSRD) was used (Hargraves et al., 2003; cited in Pratt, 2006), so that students could have uninterrupted access to their group work as it took place. The small group work was 25 minutes long. Following the session, the female participant was interviewed to gather reflections and impressions about aspects of the lesson video while watching it back with the interviewer.

Three components of Engle, Langer-Osuna, and de Royston's *Influence Framework* (2014) form the basis of the analytical approach used in this case study, with the aim of building an understanding of girls' experiences in terms of equity, when working in mixed gender collaborative groups:

How much access does the participant have to the conversational floor within the group?

To what degree do other students within the group take up or respond to the ideas of the participant?

How is the participant spatially oriented in relation to other students within the group?

The lesson video and the VSRD student interview responses are analysed separately in this paper. Firstly, the lesson videos are analysed in relation to the three components of the *Influence Framework*. To do this, group interactions are organised into four episodes, and recorded as numbered proposal negotiation units to present a narrative of group interactions (Engle et al., 2014). Secondly, VSRD is used to elicit responses from the female participant. Interview questions relate to the three components of the *Influence Framework*.

Findings and Discussion

Episode One

The problem (Figure 1) had been introduced by the teacher and the group had time to think about the problem individually before they talked with the group.

Rosary Beads Task

October is the month of the Rosary. Room 8 is planning to celebrate the month of the Rosary by making a set of Rosary beads for each student. We have to figure out how much string we will need, and how many beads...We will be working in groups of three.

How much string will we need for three students to make their Rosaries?

How many beads will we need for three students to make their Rosaries?

Figure 1. Rosary bead mathematics task.

The initial episode shows how Luci's idea was assessed by Dev and Jordan and how she was positioned as a lower status member of the group:

- 1 Luci: We could measure our necks like this...
- 2 ...to find how long the string should be
- 3 [puts the measuring tape around her neck and makes the shape and size of a Rosary]
- 4 Dev: But we're not going to wear it
- 5 Jordan: Yeah we are
- 6 Dev: No we're not
- 7 Luci: Yes we are
- 8 Dev: No we're not
- 9 Luci: Okay
- 10 Wait, I thought we were going to wear them
- 11 Jordan: [picks up beads]
- 12 We need to do this
- 13 [looks for different coloured beads]
- 14 Luci: [Keeps working with the measuring tape to find the length of string needed to make the Rosary but does not talk about her idea with the boys]

The idea put forward by Luci was of merit and could have led to further discussion among the group. However, Luci's idea was immediately challenged by Dev. Langer-Osuna (2016) suggests that when girls give directions to male peers, they are frequently rejected as inappropriate, adding to feelings of marginalisation within a group. Luci initially defended her idea, but then publicly agreed with Dev, demonstrating an acceptance that Dev had higher status and more intellectual authority than she did. Luci continued to work with the measuring tape to find the measurement that the problem asked for, but she did not talk about what she was doing with the others. Although Luci was part of a social group, her mathematical practice became private because her idea was devalued by her peers.

For the following 5 minutes Luci spoke for a total of 16 seconds and was given the pen by Jordan, so that she could record his ideas. While her spatial orientation remained consistently open to the group throughout this episode, the boys turned away from Luci, to face each other. When asked about this episode Luci responded:

Jordan told me to write his ideas, but he didn't ask about mine... I felt weird because I wanted to have my ideas heard. They're not answering the question. When I talked they cut me off... I felt angry and disappointed... Jordan is in charge because he decided to be in charge.

The interaction positioned Jordan as the most authoritative and Luci as the least authoritative, coerced into a subordinate role despite the merit of her initial idea. For Luci, having her idea rejected led to her withdrawal from the conversational floor. She was assigned a role that did not require her to share her thoughts and her equitable access to learning was denied by both Dev and Jordan because her ideas were not valued, and she was positioned as low status.

Episode Two

Following nearly two minutes of Luci's silence, and in the absence of a solution path, a teacher intervention was used in an attempt to reposition Luci as a "local authority" (Engle et al., as cited in Langer-Osuna, 2017, p.239) in the context of the mathematical task. Prior knowledge of the student's family life enabled the teacher to call on Luci's knowledge and experience of using a measuring tape with her nana:

- 15 Teacher: Luci, have you seen anyone using a measuring tape before?
16 Jordan: I have
17 Luci: Yes. My um...
18 Jordan: I have. My mum...
19 Teacher: That's good but hold on please Jordan, you are interrupting Luci
20 Luci: My nana makes clothes so she uses it
21 Teacher: Luci has seen her nana use a measuring tape, so she might be a good person to listen to when you're working together on this problem
22 Jordan: [Gets up and moves away from the group to get a tissue...
23 Comes back and sits down with the group]
24 Luci: We could measure around your neck to see how long each Rosary will be
25 Jordan: [blows his nose while Luci is talking]
26 Dev: [Gets up and leaves the group...
27 ...walks outside the room]
28 I just need to go toilet
29 Jordan: Okay
30 [Gets up to put his tissue in the bin...]
31 Luci: It's about 74 centimetres...
32 Jordan: [Returns and sits down]

Apparent in this episode is how spatial positioning reflects attitudes about intellectual authority (Engle et al., 2014). While Luci's idea was logical and presented in a clear way with the use of appropriate materials to support her reasoning, both boys were unable or unwilling to engage with her idea either verbally or spatially. By proposal negotiation unit 30, Luci was explaining her reasoning, but neither of the boys were present to listen to her. Therefore, while the teacher repositioning of Luci as a local authority did give her increased access to the conversational floor, the boys quickly denied her that access by removing themselves spatially.

Luci explained what she thought about this episode:

He's being rude to me but I keep talking anyway. I felt annoyed because he's not even listening to me. It's disrespectful. I listened to him but he didn't listen to me.

In terms of equitable access to learning, in this episode all of the students were prevented from meaningfully engaging with mathematical reasoning, because there was a lack of the necessary prosocial skills required in order for equitable group-work to take place (Anthony et al., 2016).

Episode Three

This episode outlines a teacher directed group conversation where students were asked to reflect on, and share their thoughts about the importance of fairness and respect when working collaboratively with others:

- 33 Teacher: Luci, how do you feel about the way your group are working together on this problem?
34 Luci: I feel angry... because I listen to their ideas and they don't do that for me
35 Teacher: What do you think about that Dev and Jordan?
36 Jordan: I think it's bad because it's not nice and you should listen
37 Dev: I think I'm sorry Luci
38 Luci: It's okay
39 Teacher: Is it fair to not listen to other people in your group?
40 Luci: No
41 Dev: It's not fair because we need to share
42 Jordan: Like share your idea
43 Teacher: So how can we show respect to each other when we are working together?
44 Jordan: Be fair to them
45 Luci: Listen to their ideas

During the teacher intervention, students articulated their awareness of the importance of showing respect and listening to other peoples' ideas. The aim of this episode was to redistribute status within the group, in order to best ensure equitable access to learning for all students. By directly and explicitly raising the issue of fairness, the teacher facilitated a group conversation where ensuring equity became a focus for the group as they continued to work on the task, leading to greater access to learning for all group members (Langer-Osuna, 2016).

Episode Four

The following episode demonstrates how an explicit discussion about prosocial skills and fairness led by the teacher facilitated the group to begin to work in a more effective manner and re-positioned the students more equitably in terms of their status within the group:

- 46 Luci: If we all have measuring tapes we can all measure how much string we will need
47 Dev: Okay [picks up a measuring tape]
48 Jordan: [Picks up a measuring tape and begins measuring around his neck]
49 My one is almost up to 100 centimetres
50 Dev: Mine is 84 centimetres
51 Luci: Mine is 74 centimetres
52 Jordan: Is this R.E or maths?
53 Luci: So yours is 100 centimetres?
54 Jordan: Yeah
55 Luci: [Records on sheet of paper]
56 Dev: And mine is 84 centimetres
57 Luci: [Records on sheet of paper]
58 And my one is 74 centimetres
59 [Records on sheet of paper]
60 Okay, so we need to add this all up
61 Jordan: Okay, I think it's going to be in the two hundreds

This episode demonstrates a more equitable interaction between group members. Luci repeats her initial idea, but this time the boys listen and respond. They follow Luci's direction and engage in a mathematical discussion towards a shared solution path. In this

example, the teacher intervention was not about positioning Luci as a local authority, but more explicitly about equity. Luci reflected:

It was more fun because we did it together. We listened to each other.

Student interactions from episode four show that they could take turns, share ideas and discuss a solution path. Spatial equity is another feature of this episode (Esmonde, 2009). Students stayed together, facing each other as they used the measuring tapes, and Luci recorded measurements on a sheet of paper placed in the middle of the group. The conversational floor was shared between the three students, and all mathematical contributions were valued verbally by other group members. The ideas of all participants contributed to the success of the group as a whole.

Conclusions and Implications

The four episodes outlined in this case study provide insights into issues affecting equity for girls participating in collaborative problem solving. They also demonstrate that teacher interventions can influence the ability of a mixed gender group of students to work effectively and equitably towards a shared solution path. While the repositioning of Luci as a local authority did eventually have an impact on the success of the group, it was only after the teacher had explicitly raised issues of equity, drawing out what the students already knew about the importance of listening, taking turns and showing respect to others, that the group was able to work productively and engage in shared mathematical reasoning.

Episodes one and two show that the boys were initially unable, or unwilling to engage with Luci's idea, regardless of its merit. Rather than participating in a mathematical dialogue about why they did not think her idea was worthy of attention, they instead denied her access to the conversational floor by either marginalising her spatially, or by discounting her suggestion without mathematical justification. Skelton et al. (2009) suggests that seven to eight-year-olds draw particularly heavily on societal gender stereotypes when they interact with each other. While it is difficult to measure the validity of this position within the scope of this case study, it may be fair to suggest that aspects of the dominant culture's gender narrative exist within any classroom, and that student interactions may be affected by these subtle discourses (Leyva, 2017). Episodes three and four demonstrate the impact that attending to social equity can have in engaging students more effectively in mathematical reasoning, and ensuring that all students can access learning opportunities.

There are a number of implications for teachers in mathematics classrooms where learning takes place in collaborative, dialogic groups. Firstly, because students are required to work collaboratively in an environment where risk taking and the sharing of mathematical reasoning occurs, the classroom culture needs to place high value on equity, and respect for the contributions of all students. To do this, teachers need to explicitly attend to matters of equity, both as part of the setting up of class norms, as well as when issues arise within collaborative groups. Students' attitudes and ideas about masculinity, femininity and gender should be openly discussed and challenged in relation to equity. Similarly to the DMIC formative intervention's encouragement of task design contexts that empower students from diverse cultural backgrounds (Bills & Hunter, 2015), mathematical problem contexts employed by teachers should serve to foster positive ways for students to relate to one another, regardless of gender, with the overall goal of creating a classroom culture where diversity in all forms is a focus for celebration rather than an area of prejudice and misunderstanding.

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